FASHION MASS CUSTOMIZATION SUPPLY CHAINS WITH CONSUMER RETURNS: COORDINATION AND SUPPLY CONTRACTING

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Abstract

In the fashion industry, providing customized products (or service) and satisfying the segmented market requirements are critically important. As a result, mass customization (MC) has become a popular business trend in recent years. At the same time, the quick response strategy has also emerged as a popular strategy because of its high efficiency in helping fashion companies reduce the forecast error by incorporating updated market information into the inventory decisions before the start of the selling season. A combined application of these two strategies thus makes the fashion supply chain totally different from the traditional fashion supply chain, which deserves deep investigation.

On the other hand, the short-season characteristic of fashion products often leads to a huge number of leftover products to the fashion companies, referring to various unsold items, product recalls, warranty returns, damaged goods and unwanted products. Furthermore, due to the fierce competition in the fashion industry, fashion companies always tend to offer additional and generous agreements for consumers to return their products, especially for some special programs like the online shopping and the mass customization program, which would positively influence the consumers' purchasing behavior. As a result, an effective management of the unsold leftovers and consumer returns is crucial to every fashion company.

However, the supply chain systems, including the fashion mass customization supply chains, are widely acknowledged to fail to be optimal by themselves under a decentralized mode of operations (i.e., it is not coordinated). This consequently leads us to explore what kind of supply chain contract can help achieve supply chain coordination for the fashion mass customization supply chains in the presence of consumer returns.

Therefore, motivated by the importance of consumer returns, the versatility of supply chain contracts and the under-explored fashion mass customization

supply chains under quick response, this thesis is developed and it aims to (i) investigate the supply chain of the fashion companies which adopt mass customization with quick response and permit consumer returns, and (ii) examine the performance of some supply chain contracts in coordinating the channel.

In this thesis, we first conduct a detailed literature review on supply chain contracting with consumer returns and examine how supply chain contracts perform differently in various supply chain links with consumer returns. Aspects like the categories of supply chain contracts, different links in the supply chains, the number of participating members and different channel leaderships are deeply investigated. Then a hybrid approach based on the combination of both empirical and analytical studies is adopted. Under the hybrid approach, the in-depth case study on two fashion brands, which has launched the MC program and provided consumer returns policies, is firstly conducted. The selected cases present the current situation of MC practices in the fashion industry and empirically show the significance of the topic and motivation for the analytical studies. Afterwards, mathematical modeling (based on the newsvendor model, Bayesian updating and mean-variance theory) approach is applied, followed by various different numerical analyses. The related analytical results show many important theoretical findings which help explain real world observations from the fashion industry. For instance, the impacts brought by the quick response strategy and different salvage values of consumer returns as well as unsold inventories are revealed. The supply chain contracts that can lead to a win-win outcome and coordination for the mass customization fashion supply chain are also explored. The research findings derived from the proposed models in this thesis, like the unique advantages of the quick response strategy and the industrial measures for MC scheme improvement, can make a great contribution to the literature, especially in the field of the MC program. Moreover, this thesis can also serve as a helpful reference to the industrialists in the fashion industry on MC programs and the respective consumer returns policies.

Acknowledgements

The world of knowledge, as we all know, is just like the deep ocean, which is colorful together with plenty of under-explored areas. These under-explored domains motivate the constant pursuit of various worldwide scholars on exploring something new in the existing academic world. This process can sometimes be frustrating because of the occurrence of some unexpected challenges and difficulties. However, it can also be inspiring whenever we overcome the challenges and difficulties, and identify something new.

Through my three years' Ph.D. study period, I firstly would like to express my most sincere gratitude to my Ph.D. chief supervisor, Prof. Jason Choi, for all the advice and helpful suggestions, as well as the contributions, the time, the tolerance and the care he has given to me. I still can remember the time when I started my Ph.D. study, I knew little about the academic world and felt confused about the future direction of my academic path, which made me a little bit depressed. However, fortunately, this emotion did not last long since Prof. Choi is a very good supervisor. He is tolerant and patient to me, and has taught me a lot about related academic knowledge as well as how to be a good researcher. He gives me enough time to learn new things and enough freedom to explore the research topics that I am interested in. Consequently, with the great help and guidance offered by Prof. Choi, I am very glad to see my advancement in the academic knowledge, as well as the better understanding on myself.

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Table of Content

1. Introduction

1.1 Background of Study

A fashion supply chain covers all activities related to the production and sale of fashion products, such as material preparations, product design and development, product manufacturing and processing, as well as product distribution and replenishment. A huge number of people and materials are included in these activities. Correspondingly, fashion supply chain management is defined as the planning and management of various logistics management activities in a fashion supply chain, which can be under the leadership of the retailer or other related players in the chain (Choi, 2014a; Xiao et al., 2014; Shi et al., 2017).

In the field of fashion supply chain management, given the excellent efficiency of mass customization (MC)[1] in providing customized products (or service) and satisfying the segmented market requirement, it has become a popular business trend in recent years (Da Silveira et al., 2001; Alptekinoğlu and Corbett, 2008; Fogliatto et al., 2012). Fashion brands like Burberry, SuitSupply, Indochino, Adidas, Nike, Dorothy, Shoes of Prey and Lands' End are all famous instances of the MC program actors. At the same time, the quick response strategy has also been widely applied in the fashion supply chain nowadays (Choi, 2014a), which is the result of the fierce competition in the fashion industry. Some fashion brands adopting quick response are Zara, Uniqlo, Hennes & Mauritz (H&M) and Marks & Spencer. To be specific, the quick response strategy is a strategy that aims at shortening the lead time, which can in turn lead to a higher efficiency in gathering the demand information of related items from the consumer market since the order can always be placed much closer to the selling season. Notice that, considering the high demand uncertainty in the fashion industry (e.g., from the ever changing fashion trends and the preference of customers), quick response can directly help fashion companies reduce the forecast error by combining market information into

[1] This is an innovative market strategy based on the combination of the basic mass production environment and further customization processes after receiving specific consumer requirements, which can effectively differentiate the involved brand with its competitors and help achieve a higher service level.

inventory decisions before the start of the selling season. Such kind of error can be substantial (Iyer and Bergen, 1997). Moreover, the quantity of each order under the quick response strategy is also assumed to be relatively small compared to the traditional supply chain. As a consequence, both the characteristics of mass customization and quick response strategies make the corresponding fashion supply chain model totally different from the traditional fashion supply chain, which requires deep investigation from the research area.

On the other hand, in the literature, sustainability and green supply chain management have emerged as two research streams that are popular in recent years (Vachon and Klassen, 2008; Sundarakani et al., 2010; Choi, 2014b; Dubey et al., 2017; Köksal et al., 2017). As a remark, for "sustainability", it contains three pillars, referring to environmentally, economically, and socially sustainable (Huang and Rust, 2011). The leftover products in the fashion industry, for instance, can substantially decrease the sustainability performance of the fashion companies, which not only reduce the companies' profit but also cause harm to both the environment and residents (e.g., the waste clothes sent to the landfills). These leftovers can result from unsold items, product recalls, warranty returns, damaged goods, and unwanted products. Furthermore, due to the fierce competition in the fashion industry, fashion companies tend to offer additional commercial agreements for returns to the consumers, especially for some special programs like the online shopping and the mass customization program, aiming at positively influencing the consumers' purchasing behavior. The number of these leftovers can be huge. According to the report named "Making Returns a Competitive Advantage", which is published by Narvar on June 2017[2], 48% of the online shoppers surveyed returned their purchased items last year. Besides, the Council for Textile Recycling has announced that the annual textile waste thrown away by the common American is 70 kilos.[3] Similar cases can also be found in China.

[2] Refer to http://see.narvar.com/rs/249-TEC-877/images/Narvar_Consumer_Survey_Returns_June2017.pdf for more details of this repost, which has surveyed nearly 700 online shoppers who are all US consumers.
[3] This is derived from a news released on October 16, 2017 (http://fashionlot.info/africa-vs-the-usa-a-secondhand-clothing-showdown-global-currents/), which discusses the discarded clothes.

These aspects consequently lead to the worldwide emphasis on minimizing wastage in the fashion industry. For instance, a target of manufacturing 4.5 million tonnes of recycled textile by 2020 has been set in 2016 for the Chinese textile manufacturers.[4] As a result, it can be seen that the ways to handle the unsold leftovers and consumer returns are very important concerning these three criteria, and an effective management of consumer returns is expected to every fashion company, regardless of whether the fashion company is using the quick response/mass customization strategy or not. However, from another side, the supply chain systems, including fashion mass customization supply chains, are widely acknowledged to fail to be optimal by themselves under a decentralized mode of operations (i.e., it is not coordinated). This leads us to explore what kind of supply chain contract can help achieve supply chain coordination[5] for the fashion mass customization supply chains in the presence of consumer returns.

1.2 Research Objectives

Motivated by the importance of consumer returns, the versatility of supply chain contracts and the lack of related studies in fashion mass customization supply chains that have combined these two issues, the purpose of this research study is to investigate the supply chain of the fashion companies which adopt mass customization and permit consumer returns, and examine the performance of some supply chain contracts in coordinating the channel. To be specific, we have four main objectives as follows:

1. To conduct a comprehensive review of the recent literature on supply chain contracts in the scope of consumer returns. The main focus is to examine how supply chain contracts perform in different links when the consumer returns are allowed and to classify the literature with respect to different channel leaderships as well as the number of participating members.

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[4] Related information can be found in the link of http://fashionlot.info/chinas-sustainable-fashion-paradox-global-currents/.

[5] In the field of logistics and supply chain management, the term "coordination" refers to the scenario when the supply chain system is optimized.

2. To analytically analyze the fashion supply chain which adopts a mass customization program with consumer returns and study the impacts brought by the quick response strategy under that program. That is, we are interested to examine whether the quick response policy can benefit the involved members in a mass customization fashion supply chain with consumer returns.
3. To explore the supply chain contracts that can lead to a win-win outcome for the mass customization fashion supply chain. The aim is to guarantee the performance of the parties who participate in the program and finally enhance the performance of the whole channel.
4. To further extend the analysis to the case of different salvage values of consumer returns and unsold inventories under the mass customization program. In addition to the investigation on coordination contracting mechanisms, various industrial measures to improve the performance of the mass customization program will also be discussed.

1.3 Outline of Methodology

In this thesis, the analytical modelling approach based on the observations from real industrial cases (see Figure 1.1) is adopted for deriving important research findings and useful managerial insights, and the details are explained as follows:
(1) Firstly, in-depth case study on two fashion brands which has launched the MC program and provide consumer returns policies is employed, which aims at presenting the current situation of MC practices in the fashion industry. This also empirically shows the significance and motivation of later analytical studies.
(2) Mathematical modeling (based on the newsvendor model, Bayesian updating and mean-variance theory) approach is applied, followed by various different numerical analysis scenarios. The related analytical results show important dimensions which are different from the case study, and help explain real world observations from the fashion industry.
Therefore, it can be observed that the hybrid approach of this thesis, as is

introduced above, can help us better understand the MC practice in the fashion industry and provide useful references to both interested researchers and related fashion brands.

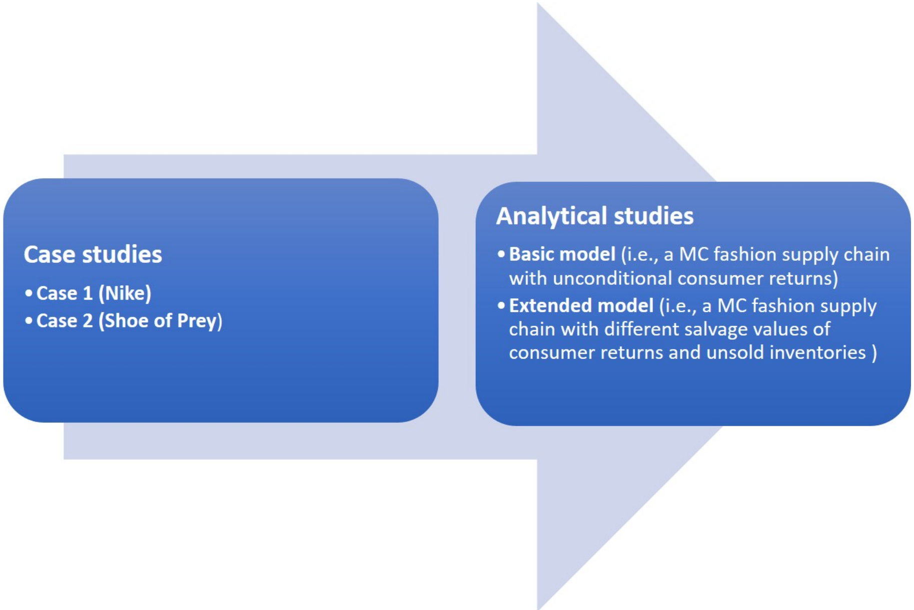

Figure 1.1 Outline of Methodology

1.4 Contributions and Organization

This thesis contributes to the existing literature by providing innovative research findings and important managerial insights on the fashion MC program with consumer returns, which is widely implemented in practice. The research findings derived from the proposed models in this thesis, like the unique advantages of the quick response strategy and the industrial measures for MC scheme improvement, can make a great contribution to the literature on the fashion industry, especially in the field of the MC program. Moreover, this thesis can also serve as a helpful reference to the industrialists in the fashion industry which has launched the MC program and provide consumer returns policies.

The organization of this thesis is as follows. We present a detailed literature review on supply contracting issue in the supply chains with consumer returns in Chapter 2. Various aspects of this area, such as the categories of supply chain contract, different links in the supply chains, the number of participating members and different channel leaderships, will be deeply investigated. Then in Chapter 3, real cases related to the consumer returns in the fashion industry will be explored under the background of the MC program. This is followed by the analytical analyses on a fashion supply chain in Chapter 4, which adopts the mass customization program and allows unconditional consumer returns. The performance of the quick response strategy is deeply compared with the results derived from the case without quick response in this chapter. Afterwards, an extended study is conducted in Chapter 5 by additionally considering the case of different salvage values of consumer returns and unsold inventories, which is assumed to be the same in Chapter 4. Finally, findings from the quantitative study, the originality and contributions of this thesis, as well as future research directions are discussed in Chapter 6.

1.5 Publications Derived from this PhD Thesis Research

1. Guo, S., Shen, B., Choi, T. M., & Jung, S. (2017). A review on supply chain contracts in reverse logistics: Supply chain structures and channel leaderships. Journal of Cleaner Production, 144, 387-402.
2. Choi, T. M., & Guo, S. (2018). Responsive supply in fashion mass customisation systems with consumer returns. International Journal of Production Research, 56(10), 3409-3422.
3. Guo, S., Choi, T. M., Shen, B., & Jung, S. (2018a). Coordination and Enhancement Schemes for Quick Response Mass Customization Supply Chains with Consumer Returns and Salvage Value Considerations. IEEE Transactions on Systems, Man, and Cybernetics – Systems, in press.
4. Guo, S., Choi, T. M., Shen, B., & Jung, S. (2018b). Inventory Management in Mass Customization Operations: A Review. IEEE Transactions on Engineering Management, in press.

2. Literature Review

Since consumer returns, supply contracting as well as mass customization are three major focuses of this thesis, literature related to the topics of consumer returns in supply chain management, supply contracting in fashion supply chains, supply contracting with consumer returns, and mass customization supply chain management will be deeply discussed in this chapter.

2.1 Consumer Returns in Supply Chain Management

Due to the increasing competition in retail industry nowadays, customer returns have become a very common element in a supply chain, which is a result of pursuing higher customer satisfaction. However, it also leads to a big challenge, not only owing to the difficulty in assessing the quantity, quality and timing of consumer returns, but also because it is always costly (e.g. unconditional full refund) and problematic, especially for perishable products like fashion items and high-tech products (Ghoreishi et al., 2014). Meanwhile, consumer returns can also be a significant challenge for manufacturing firms if their objectives are to sell new products to forward customers rather than gaining revenues from remanufacturing activities (Mollenkopf et al., 2011). That is, in the presence of consumer returns, manufacturers will face additional collection costs and disposal costs. Owing to these disadvantages, the involved players in the chain may behave in a non-cooperative way, which can hurt the entire chain and requires suitable coordination mechanisms. Therefore, it is a topic that is widely studied in the research area in various aspects.

Among these aspects, the papers devoting to the analyses of customer loyalty will be discussed first. As a remark, the loyalty of consumers is a feeling generated from previous positive purchasing experience, which can be a result of the location of the store, the availability of the items, and the offered returns policy. Once formed, it can be a strong preference when the consumer has to select one product from several similar items. Krumwiede and Sheu (2002) argued that the companies' attitudes towards the consumer returns would ultimately influence the loyalty of their customers and the final sales. Therefore, they reviewed current industry practices in handling the consumer returns, such as the participation of third-party providers, to help companies effectively manage consumer returns. Ramanathan (2011) explored the performance of the companies in handling consumer returns under the consideration of the risk characteristics of products by dividing the products into low-risk products and high-risk products. They found that handling consumer returns can efficiently enhance the loyalty of consumers for both low-risk and high-risk products.

There are also many papers exploring the uncertainty of consumer returns, which is a concept defined as a set of various situations with totally different quality or quantity levels of the returned items. Sheu et al. (2005) believed that the consumers' willingness to return used products can differ a lot and therefore the quantity of returns was also unknown. They regarded the rate of consumer returns, together with the corresponding subsidies offered by governmental organizations, as two strategic factors. Xiao and Shi (2016) developed a supply chain in which the assistance provided by retailer can help reduce the quantity of consumer returns. The authors discussed both the case of full information and information asymmetry and explored their respective influence on the final consumer returns rate as well as the handling cost of consumer returns. Different from the above discussion on the quantity issue, Crocker and Letizia (2014) investigated the quality uncertainty of consumer returns and the disposition of consumer returns in the early stage. They developed a supply chain structure in which the retailer can either send the returned products back to the manufacturer or directly refurbish them and then resale, and showed the significance of returns policies which can contribute to the timely processing on the consumer returns. Pinçe et al., (2016) studied the uncertainty on the residual value of consumer returns and solved the challenging problem of maximizing this value on the basis of deep discussion on the ways to classify and allocate different consumer returns. Zeballos et al. (2012) addressed the uncertainty in the both quality and quantity of consumer returns and assumed that the sorting centers would classify the returns into three different quality levels (i.e., good, medium and bad). Besides, aiming at achieving profit maximization, the authors translated the uncertainty into one of operational decision parameters in the model. Another different case is the one established by Guide et al. (2003), in which more than three kinds of uncertainties sources were considered. These sources comprised the volume, the timing and the quality of the consumer returns, the complexity for remanufacturing and the difficulty to test and evaluate, as well as the internal characteristics of these returns (e.g. different lifetimes). The authors explored the impact of these factors on the final performance of the closed loop supply chains.

Another close research area is the collection of consumer returns. It is a series of activities related to acquiring corresponding items from one point and then delivering them to another point for further processing. It includes the acquisition, transportation, and storage of these items. Kumar and Malegeant (2006) argued that the collection cost of consumer returns can be a substantial part of total costs in any channel and investigated the scenario when the manufacturers cooperated with an eco-non-profit community organization to collect consumer returns. Du and Evans (2008) explored a bi-objective optimization model (minimize both of the total costs and the total cycle time) by focusing on the collection of warranty returns among kinds of consumer returns. The authors assumed that the manufacturer preferred to collaborate with the third party collector and decisions about the collection locations and the transportation flows between collection and repair sites were addressed. Genc and De Giovanni (2017) analyzed the impacts of collection efforts and solved the question of who should collect the returned products from consumers under the assumption of a price and quality dependent consumer returns rate. Specifically, the authors explored the price issue from both the sides of wholesale and retail prices, while the quality was mainly dependent on the applied technologies. Huang and Wang (2017) analyzed three different collection models of consumer returns, i.e., collected by the manufacturer, the distributor and the third party collector respectively, which were related to different remanufacturing scenarios. The authors compared the performance of these models from the perspectives of economical and environmental benefits.

In addition, the consumer returns are treated as something that can induce extra costs to the involved players, such as the further processing cost of returns and the refund paid to the customers, and therefore some papers also have investigated the pricing and order decisions under the condition of consumer returns in the channel. For example, both Chen and Bell (2009) and Ghoreishi et al. (2015) discussed the optimal decisions on the selling price and the inventory policy, under the consideration of the negative effects of customer returns, and treated the final quantity of returned items as a function of both the market demand and the product price. Shulman et al., (2011) investigated a competitive environment with various differentiated products under the consideration of consumer returns, which was a result of the misfit of the products with their preferences or their value evaluation. The authors emphasized the significance of consumer preferences when making decisions on the price and restocking fee. Chen and Zhou (2014) explored the optimal decisions for perishable items supposing that the amount of consumer returns was independent of the market demand. They integrated the retailer's loss aversion decision bias into the investigation of the retailer's ordering policy and assumed customer returns are allowed with full refund during the sales season. Ülkü and Hsuan (2017) considered the case when the consumers were environmentally conscious and deeply examined the influence of consumer returns on the pricing decisions of the firms in a competing market.

2.2 Supply Contracting in Fashion Supply Chains

Fashion items are known as short life cycles products which face long procurement lead times and high demand uncertainty. These aspects pose great challenges to the inventory management and can easily hurt final magnitudes of the channel profits in a decentralized supply chain system. As a result, the efficient application of coordination mechanisms between two adjacent players, like the returns policies, is strongly suggested so as to motivate players to cooperate in a way as if they are under a vertically integrated supply chain setting. These also lead to various research works focusing on supply contracting in fashion supply chain with different considerations.

The first example is the consideration of information updating in the fashion supply chain. It is an action that allows the retailer to postpone the ordering time for the corresponding items and to obtain more demand information from the market before placing an order (Donohue, 2000). This can substantially decrease forecast errors and plays a significant role in inventory management. Yang et al. (2011) considered a fashion supply chain with one retailer and two complementary suppliers, which held different lead times, under both exogenous and endogenous retail price cases. Besides, during the time interval between the orders placed to these two different suppliers, the retailer was assumed to be able to update its demand forecast for the fashion product and the return policy as well as a revenue sharing contract was also proposed. Chen et al. (2010) formulated a two-stage optimization model for a manufacturer–retailer fashion supply chain. In their model, the manufacturer decided the amount of capacity reservation in the first stage, and after observing the market demand information, the fashion retailer would determine the order quantity and the retail price in the second stage. In addition, in order to align these two self-interested players, a risk-profit sharing contract was proposed where the retailer shared part of the over-reserved capacity cost with the manufacturer but benefited from the reserved capacity when it was sufficient.

Another related research field is the information sharing, referring to the information about the inventory service level, market demand and shortage allocation policies. This information can lead to substantial amount of potential costs and therefore every player in the chain prefers to elicit information from others as much as possible. Kurata and Yue (2008) explored the incentives to motivate the manufacturer and retailer in a fashion supply chain to shift from an off-invoice trade promotion mode to a scan-back trade mode, which was dependent on the information sharing about the retailer's sales between these two members. By comparing the performances of a flexible quantity contract, a revenue sharing contract, a quantity discount contract, and the buyback contract, the authors found that only under a buyback can both of these two members as well as the whole chain attain higher profitability from the new mode. Yu et al. (2014) studied a two-stage game framework in a fashion supply chain including one retailer and one salesperson, under an asymmetric information-sharing environment. A quota-based compensation plan was provided by the retailer to aiming at acquiring more information about the market demand from the salesperson.

Besides, it is widely acknowledged that the risk preference, or the net difference between the risk preferences of different members in a same supply chain, is a concept that can substantially decide the achievability of coordination for the entire supply chain. For instance, a risk-neutral retailer may fail to coordinate with a risk-averse manufacturer owing to the huge difference between their attitudes towards the risks in their operations. Choi et al. (2008) investigated the coordination issue in a fashion supply chain when the individual players are influenced by their own risk preference (i.e., risk averse, risk neutral and risk prone) under a mean-variance model. They found that the consideration of risk preferences of the players was very important since it can directly impact the final coordination of the whole chain, by examining a wholesale pricing contract case. Xu et al. (2013) proposed a fashion supply chain structure in which the manufacturer was risk-neutral whereas the fashion retailer was risk-averse. They studied the effectiveness of both single supply chain contracts (i.e. the revenue-sharing contract and the two-part tariff contract) and a hybrid contract in achieving channel coordination. Shen et al. (2014) explored a manufacturer-retailer fashion supply chain selling either a national brand fashion item or a private label fashion product. The authors investigated these two players' performances under both a markdown contract and a profit sharing contract. They concluded that their relative risk performances were quite similar but the absolute risk performances differed a lot, which can be a crucial implication for risk-averse the retailer.

In addition to the above aspects, as short lifecycle products, the fashion items are always suffered from a high variability of the market demand, which lead to the extreme difficulty in balancing the supply and the demand and requires suitable coordination policies to help decrease costs. Nair and Closs (2006) compared the retail environment of fashion products with a benchmark situation of low demand variability. At the same time, the performance of a markdown policy was also analyzed, including the sales revenue, inventory holding cost, cost of lost sales and others, which indicated that higher demand variability can induce higher performance of the markdown contract. Wei and Xiong (2015) examined a fashion supply chain involved in a price and sales effort dependent demand environment. The authors assumed that investment fee on the sales effort can be undertaken either by the retailer or the manufacturer and specified two supply chain contracts, referring to the revenue-sharing contract and the wholesale price contract, to compare the differences between the optimal decisions and corresponding profits of these two players and their performance. Arani et al., (2016) proved the performance of a revenue-sharing contract to coordinate the retailer-manufacturer fashion supply chain when they make separate decisions on the order and production quantity in a case of a stochastic demand as well as a stochastic retail price. Two leadership situations were discussed and compared by the authors, i.e., the leadership of the retailer together with the leadership of the manufacturer. Wang et al., (2016) proposed a buyback contract to coordinate a dual channel system (i.e., a direct channel owned by the fashion brand together with an indirect channel charged by the fashion retailer), which suffers from price competition and demand uncertainty. Different results of the emphasis on the environmental sustainability and economic sustainability were discussed, respectively. Shen et al., (2017) considered the effects of social influences and developed a special fashion supply chain in which the services offered to different consumers were different. The authors compared the performance of a quantity discount contract, a capacitated linear pricing contract, as well as a profit sharing contract in coordinating the retail price and online retail services decisions.

The performance of a supply chain contract can differ a lot under different considerations, such as the four aspects shown above. It is therefore necessary to design a differentiated supplying contract for each specific supply chain. With this consideration, this thesis innovatively investigates the supply contracting issue in the fashion industry by integrating the effects brought by the information updating together with the existence of consumer returns as well as unsold items, which also complements the existing literature on supply contracting in the fashion supply chains.

2.3 Supply Contracting with Consumer Returns

In recent years, the increasing significance and popularity of the "sustainability" concept, has attracted plenty of researchers studying the field of consumer returns. However, existing studies focusing on the coordination issues of supply chain systems with consumer returns are relatively scattered, which plays a crucial role in affecting the performance of the whole system. Therefore, motivated by the importance of supply chain contracts and consumer returns, this thesis conducts a comprehensive review of the recent literature on supply chain contracts in a supply chain with a focal point on consumer returns in the following[6], the results of which also provide a crucial reference for the later analytical model design.

To be specific, how supply chain contracts are differently applied in the presence of consumer returns with respect to the supply chain structure is examined. Notice that, the supply chain structure in this thesis is presented in the form of different supply chain "links" in the following content, which refers to the relationship between any adjacent supply chain members. In fact, according to Lambert and Cooper (2000), a "link" is formed when supply chain parties have cooperation and it is these "links" that finally established a whole supply chain. At the same time, the application of suitable supply chain contracts can motivate the

6 As a remark, most part of Section 2.3 is published in Guo et al. (2017).

participation of the corresponding players and finally help them gain competitive advantages in the market (Min and Zhou, 2002). Furthermore, this thesis also explores how the channel leadership (i.e. who is the leader in the relate link) is considered in various articles when coordinating the supply chain under the consideration of consumer returns.

Besides, for a notational purpose, details of the abbreviations in this subsection are shown as follows:[7]

R: the retailer, who sells new products to the target consumers in the market;

M: the manufacturer, who produces new products and supplies them to the downstream retailer;

RM: the remanufacturer;

S: the supplier, who supplies raw materials to the contracted manufacturer;

T: the third party collector for collecting consumer returns;

X+Y: The supply chain link between X and Y, where both X and Y are supply chain members. For example, M+R means the link between the manufacturer and the retailer;

X-led: X acts as the leader. For instance, M-led refers to the case when the manufacturer is the leader in the reverse supply chain link(s).

2.3.1 Descriptive Statistics

Table 2.1, Figure 2.1.a and Figure 2.1.b show the descriptive analysis on the selected papers, which refers to the distribution of the publication years as well as journals. Specifically, Table 2.1 and Figure 2.1.a reveal an increase trend in the number of papers exploring the application of supply chain contracts in reverse logistics. At the same time, Figure 2.1.b indicates that *International Journal of Production Economics*, *European Journal of Operational Research,* as well as *Production and Operations Management* are the most closely related journals, all of which are well-established journals in the field of operations management.

[7] Notice that these abbreviations are the same with my published work Guo et al. (2017).

Table 2.1 Distribution of the publications by journals across the time period of 2006-2017 (66 articles)

Academic Journals	**Year of publication**												Total
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Journals covering more than one related articles													56
International Journal of Production Economics	1	0	1	0	2	1	2	2	2	2	3	1	17
European Journal of Operational Research	0	2	1	0	2	2	0	0	2	2	0	0	11
Production and Operations Management	1	0	0	0	0	1	1	1	0	0	0	0	4
International Journal of Production Research	0	0	0	0	0	0	1	0	1	1	0	0	3
Journal of Cleaner Production	0	0	0	0	0	0	0	1	0	0	2	0	3
Manufacturing & Service Operations Management	1	0	1	1	0	0	0	0	0	0	0	0	3
Transportation Research Part E: Logistics and Transportation Review	0	0	0	0	1	0	1	0	0	0	1	0	3
Annals of Operations Research	0	0	0	0	0	0	0	0	1	1	0	0	2
Applied Mathematical Modelling	0	0	0	0	0	0	0	0	0	0	1	1	2
Computers & Industrial Engineering	0	0	0	0	0	0	0	0	0	0	1	1	2
Journal of Intelligent Manufacturing	0	0	0	0	0	0	0	0	0	2	0	0	2

Mathematical Problems in Engineering	0	0	0	0	0	0	0	0	0	1	1	0	2
Omega	0	0	1	0	0	0	0	0	1	0	0	0	2
Journals only covering one related paper													10
4OR-A Quarterly Journal of Operations Research	0	0	0	0	0	1	0	0	0	0	0	0	1
Asia-Pacific Journal of Operational Research	0	0	0	0	0	0	1	0	0	0	0	0	1
Central European Journal of Operations Research	0	0	0	0	0	0	0	1	0	0	0	0	1
International Journal of Systems Science: Operations & Logistics	0	0	0	0	0	0	0	0	1	0	0	0	1
Journal of Optimization Theory and Applications	1	0	0	0	0	0	0	0	0	0	0	0	1
Management Science	1	0	0	0	0	0	0	0	0	0	0	0	1
Naval Research Logistics	0	0	0	0	0	0	0	1	0	0	0	0	1
Operations Research Letters	0	0	0	0	0	0	0	0	1	0	0	0	1
Production Planning & Control	1	0	0	0	0	0	0	0	0	0	0	0	1
Sadhana	0	0	0	1	0	0	0	0	0	0	0	0	1
Total	6	2	4	2	5	5	6	6	9	9	9	3	66

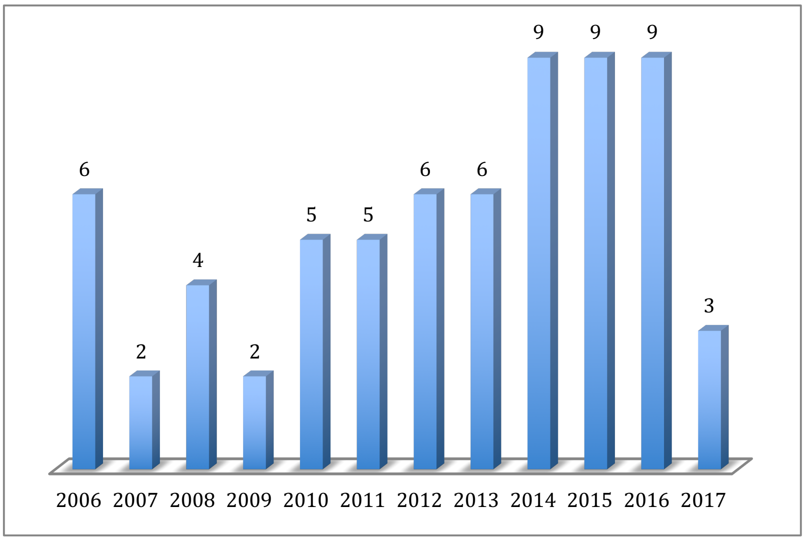

Figure 2.1.a Distribution of the publications per year across the time period of 2006-2017.

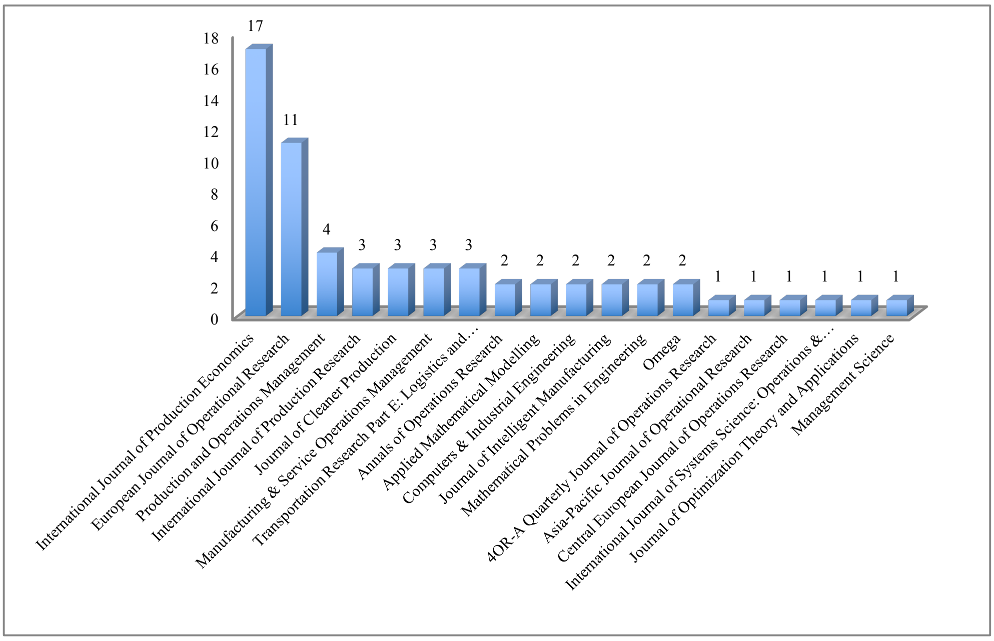

Figure 2.1.b Distribution of the publications according to different journals (66 articles: 2006-2017).

2.3.2 Review Based on Supply Chain Structure: The Links

In this subsection, the selected literature is respectively discussed according to the involved supply chain links. We first explore the papers which are analyzed under the consideration of "single link", and then investigate the papers under domain of "multiple links".

Single Link

The single link case comprises many different kinds of links in the supply chain, such as the link between the manufacturer and the retailer (M+R) and the link between the remanufacturer and the third party collector (RM+T). As for the application of supply chain contracts under the "single link" case, we divide it into two separate scenarios, one is the traditional "single contract" scenario and the other one is the "hybrid contracts"[8] scenario.

Table 2.2 Cross analyses of the supply chain contracts with involved links under Situation A

SC contracts	Involved links							
	M+R	M+S	M+T	M+RM	R+T	R+RM	RM+T	Total
Buyback and returns contract	15	1	0	0	1	0	1	18
Revenue sharing contract	7	0	0	0	1	0	0	8
Wholesale pricing contract	2	1	1	0	0	0	2	6
Two-part tariff contract	3	0	1	0	0	0	0	4
Quantity discount contract	1	0	0	0	0	1	0	2
Risk sharing contract	1	1	0	0	0	0	0	2
Consignment contract	1	0	0	0	0	0	0	1
Rebate contract	1	0	0	0	0	0	0	1
Papers mentioning more than one contracts and exploring them separately	8	0	1	1	0	1	0	11
Total	39	3	3	1	2	2	3	53

(1). Single supply chain contracts

Papers exploring the use of a single supply chain contract are investigated in the scenario of single supply chain contracts, which includes 53 articles in total[9]. The single supply chain scenario is defined as Situation A (see Table A1 in the Appendix A for the specific definitions of all "situations"), and a deep comparison

[8] As a remark, the hybrid supply chain contract is a result of the combination of multiple traditional single supply chain contracts.
[9] For more details of these 53 papers, please refer to Table A2 in the Appendix A.

is exhibited in Table 2.2 by classifying the applied the supply chain contracts into 9 sub-categories. It can be seen that, in Situation A, the most widely examined link is the link between the manufacturer and the retailer, which refers to 39 articles. Details like the specific contract terms and the involved players in each link are to be further in the following.

As a contract closely related to reverse logistics, the buyback and returns contract is the most popular supply chain contract in the literature according to Table 2.2. Under this contract, the "seller" agrees to buyback the product from the "buyer" with a certain amount (either partial or full) of refund. The products can be the leftover products (i.e., happen only at the end of the selling season) or consumer returned items under the money back guarantee scheme (i.e., happen at anytime throughout the whole selling season). Under the category of the buyback and returns contract, 15 reviewed papers explore the traditional channel returns in the manufacturer-retailer (M+R) link[10]. Differently, Huang et al. (2015) investigate the management of consumer returns in the link between the retailer and the third-party collector (R+T), Gu and Tagaras (2014) examine the application of the buyback and returns contract in the cooperative relationship between the remanufacturer and the third party collector link, while Hou et al. (2010) explore the manufacturer-supplier link.

Apart from the buyback and returns contract, the revenue sharing contract is also widely adopted among the literature. One common application of the revenue sharing contract in reverse logistics is the revenue shared by the manufacturer to the retailer, which is generated from the cost savings of conducting remanufacturing activities. The differences exist in the configurations and arrangements of the revenue-sharing contract applied in the reviewed papers are presented as follows. Zeng (2013) studies the case when a part of the manufacturer's revenues from selling remanufactured products are shared with the retailer in order to encourage the retailer to support the program. Mafakheri and

[10] Please refer to Arcelus et al. (2011), Bose and Anand (2007), Chen (2011), Chen and Bell (2011), He et al. (2006), Jeong (2012), Lee and Rhee (2007), Li et al. (2012b), Liu et al. (2014), Matsui (2010), Ohmura and Matsuo (2016), Wu (2013), Xu et al. (2015), Yao et al. (2008) and Zhang et al. (2015) for more details.

Nasiri (2013) and Zou and Ye (2015) examine the supply chain when the manufacturer would share his revenue (from recycling or reselling remanufactured items) with the retailer to compensate the collection costs spent by the retailer. Differently, Xie et al., (2017) design a dual revenue-sharing contract for a closed loop channel under the participation of one manufacturer and one retailer, which consists of an online channel and an offline channel. For the forward direction, the manufacturer enjoys the share of the offline sales revenue from the retailer. Then for the reverse direction, it's the retailer who enjoys share of the cost savings from remanufacturing activities conducted by the manufacturer in the online channel. Notice that in the above 4 articles, the retailer is responsible for collecting product returns and the manufacturer is the one who shares the corresponding revenue with the retailer. Other papers have examined the reverse supply chain in a different setting. For example, Wu et al. (2015) and Giri et al., (2017) study the supply chain in which the manufacturer is responsible for collecting used products from consumers under competitive environment. Ran et al. (2016) assume both the manufacturer and the retailer would collect used items from the market. Weraikat et al. (2016) discuss a contractual arrangement where the retailer will share extra bonus with the third party collector to motivate a complete collection of products from customers. From the reviewed papers on the revenue sharing contract, we can see that the implementation of revenue sharing takes different forms under different settings.

Reverse logistics in the presence of the wholesale pricing contract has also been examined in the literature. In fact, the wholesale pricing contract is the simplest and most commonly adopted contract in supply chain management in which there is a constant unit wholesale price offered by the wholesaler (Atasu et al., 2013; Li et al., 2012a; Chen and Wan, 2011). In the literature, Atasu et al. (2013) design a wholesale pricing contract in which the same wholesale price is offered to both the newly produced and the remanufactured items provided by the manufacturer. Li et al. (2012a) examine both the make-to-stock policy and the make-to-order system in the presence of a wholesale pricing contract. Both of these two papers explore the reverse supply chains with the wholesale pricing contract for the link between the manufacturer and the retailer. Notice that for the manufacturer-supplier link, Li and Li (2016) investigate a chain-to-chain competition concerning product sustainability. A supplier and a manufacturer in the chain where the product demand increases with products' sustainability. In addition, Hong and Yeh (2012) explore the cooperation between the manufacturer and the third-party collector via a wholesale pricing contract for collecting end-of-life products from consumers. Hong et al. (2008) and Ye et al. (2016) investigate a structure where the remanufacturer interacts with the third party collector to purchase recycled items via a wholesale pricing contract and recovers the remaining value of these products.

The two-part tariff contract is widely explored. Under a typical two-part tariff contract, the seller provides a wholesale price and also a fixed credit transfer to the buyer. In our review, four papers, have examined the two-part tariff contract, and three of which explore the manufacturer-retailer link. We review them as follows. Kaya (2010) studies a supply chain with the two-part tariff contract implemented between the manufacturer and the third party collector. In Kaya (2010)'s paper, the fixed transfer price is a price paid by the manufacturer to the third party collector in the presence of a unit wholesale price. Gao et al. (2016) set up a low wholesale price provided by the manufacturer while charging a fixed franchise fee as the channel entrance allowance. Dobos et al. (2013) consider the situation when the remanufactured items are perfect substitutes for new ones and a two-part tariff contract is specified to achieve Nash equilibrium. Hong et al. (2015) establish the condition with which the retailer takes up the role as the collector and the manufacturer offers a two-part tariff contract. In particular, the retailer provides a fixed payment to the manufacturer to compensate the loss incurred in the manufacturer level.

The other related contracts include the quantity discount contract (Huang et al., 2011; Jena and Sarmah, 2016), the risk sharing contract (He, 2015; He and Zhang, 2010), the rebate contract (Ferguson et al., 2006), and the consignment contract (Hu et al., 2014).

Moreover, since different supply chain contracts may have different performance, there are also 11 papers considering more than one kind of supply chain contracts separately. Among them, 3 papers focus on exploring different independent supply chain contracts with a goal to uncover the best one. In this scope, Chen and Chang (2014), De Giovanni (2014), and Zhao and Zhu (2015) examine the different performance of the wholesale pricing contract and the revenue sharing contract under different links in reverse logistics. To be specific, Chen and Chang (2014) consider the manufacturer-remanufacturer link where the manufacturer collects returns for the remanufacturer. De Giovanni (2014) investigates the link between the manufacturer and the retailer, and assumes the manufacturer could generate revenues from the returns provided by the retailer. Zhao and Zhu (2015) study the retailer-remanufacturer link in which the retailer is the collector and the government will offer additional subsidies to the remanufacturer.

Then the following four papers analyze the effectiveness of the buyback and returns contract and another contract separately in reverse logistics under the retailer-manufacturer link. Huang et al. (2014) and Su (2009) compare the buyback and returns contract with the rebate contract. Huang et al. (2014) assume that both returns and leftovers would be salvaged in a secondary market and Su (2009) assumes that the manufacturer could have an additional monitoring capability. Xiao et al. (2010) conduct a comparison between the buyback and returns contract and the markdown contract considering the influences of strategic factors like the salvage value and refund amount. Another comparison involving a buyback and returns contract is with the wholesale pricing contract, which is explored by Ruiz-Benitez and Muriel (2014). The authors investigate the contract which can better manage extra reverse logistics costs induced by customer returns. Different from the above, Zhang et al. (2014a) conduct a comparison between a two-part tariff contract and a collection effort requirement contract based on the retailer-manufacturer link, under a partial information sharing (on the retailer's collection costs for returns) environment.

Apart from the comparison between two contracts, there are two articles (by Song et al., 2008 and Yoo et al., 2015) which compare three different contracts in reverse logistics under the retailer-manufacturer link. To be specific, Song et al. (2008) compare efficiencies among the wholesale pricing contract, the buyback and returns contract, and the consignment contract from the viewpoints of the consumers, the manufacturer, the retailer, and the whole channel. Yoo et al. (2015) investigate the wholesale pricing contract, the buyback and returns contract and the quantity discount contract. They evaluate how each contract affects the retailer's pricing decisions and the respective return policies. Besides, Hu et al., (2016) conduct analyses on the consumer returns issue in a reverse supply chain that is comprised of one manufacturer and one third party collector. Through the comparisons on the performance of five different supply chain contracts, i.e., the wholesale price contract, the double-phase price contract, the cost-pooling contract, the subsidy contract, as well as the indemnity contract, the influence brought by the strategic behavior of consumers is deeply explored by the authors.

(2). Hybrid supply chain contracts

Supply chain coordination in reverse logistics may not be achievable by a single simple contract. To cope with this challenge, hybrid contracts, which are based on the combination of multiple supply chain contracts, can be applied. In this paper, we consider the situation where multiple supply chain contracts are combined and used together under one reverse supply chain link, as Situation B and it refers to five articles. A quick finding is that, 60% of the related articles in Situation B explore the manufacturer-retailer link (refer to Figure 2.2). We review them as follows.

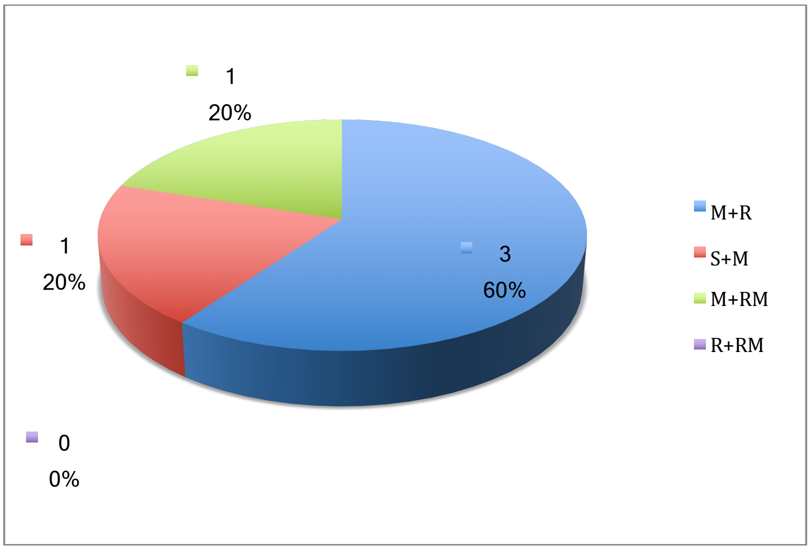

Figure 2.2 Distribution of involved links under Situation B.

Jacobs and Subramanian (2012) propose a hybrid contract including multiple parameters, like the responsibility sharing level and the recovery target, to coordinate the supplier-manufacturer link of the reverse supply chain in which both the supplier and the manufacturer are responsible for collecting and recycling activities. Savaskan and Van Wassenhove (2006) design a hybrid contract, which includes the decisions in a buyback and returns contract and a two-part tariff contract, to coordinate the channel when the manufacturer interacts with two competitive retailers to collect postconsumer goods. Chen et al. (2006) and Shi (2006) incorporate the decisions in a buyback and returns contract and a risk sharing contract into a new mechanism in order to optimize the interaction between the manufacturer and the retailer. As a remark, the major focus in Chen et al. (2006) is demand information updating while Shi (2006) emphasizes more on the risk attitude of the decision makers. Apart from the above, Chiu et al. (2011) explore a hybrid policy by combining the wholesale pricing contract, the rebate contract, and the buyback and returns contract in the retailer-manufacturer link. Components like the unit wholesale price, partial refund value for each unsold unit, and rebate value for each unit sold beyond the target sales level, are considered under this contract. Notably, the performance of these hybrid contracts highlights that sometimes a single simple contract is not enough for achieving reverse supply chain coordination and hence we need to use the hybrid contracts.

Multiple Links

We explored the single link papers above, and now present the multiple-link papers in this section. One example is the reverse supply chain which includes the retailer, the manufacturer and the third party collector (R+M+T). The analyses in this part are divided into two subgroups, which refers to the papers which focus on "multiple links only" one and the one which examines "both single link and multiple links".

(1). Multiple links only

With respect to the "multiple links only" scenario, we explore the situation when more than one links in reverse supply chains are discussed in one paper. Such situation is regarded as the Situation C and it contains 7 articles.

Among these 7 papers, two of them utilize the same contracts to coordinate multiple links in reverse logistics. To be specific, Choi et al. (2013a) examine the different performance of a two-part tariff contract and a spanning revenue-cost sharing contract which can align the incentives in the retailer-manufacturer link and the manufacturer-third party collector link simultaneously. Zhang and Ren (2016) establish a network including a manufacturer, a remanufacturer, and a retailer where a competitive market is formed between the newly produced items from the manufacturer and the remanufactured ones from the remanufacturer. They apply a mechanism incorporating both a revenue sharing contract and a two-part tariff contract to achieve the coordination among these three parties. The other 5 articles study how different contracts can be implemented to coordinate different links in the reverse supply chains. We review them as follows. Bhattacharya et al. (2006) apply two different two-part tariff contracts to the link between the retailer and the manufacturer, and the manufacturer-remanufacturer link where the manufacturer purchases remanufactured products from the remanufacturer and sells both the new and remanufactured ones to the retailer. Arshinder et al. (2009) propose two different buyback and return contracts to coordinate the link between the manufacturer and the distributor, and the link between the distributor and the retailer. They assume that the retailer can return all the leftovers back to the distributor and the distributor will further return those items back to the manufacturer. Ding and Chen (2008) explore the applicability of two different hybrid contracts, both of which combine the decisions in a buyback and return contract and a profit sharing contract, in the manufacturer-retailer link as well as the manufacturer-supplier link. In Ding and Chen (2008), the unsold inventories are also returned level by level and each member shares the cost induced by overstocking. Li et al., (2017) investigate the coordination problem of a reverse supply chain through two different wholesale price contracts, which comprises a third party collector for consumer returns, a remanufacturer, and two retailers who completes on selling remanufactured products. Apart from these papers, Yan and Sun (2012) investigate a model with a manufacturer, a retailer and a third party collector. The manufacturer-retailer link is connected by a wholesale pricing contract, while the manufacturer is linked with the third party collector under a target rebate-punish contract. One of the emphases in using the target rebate-punish contract is to ensure the right quantity of returns is provided by the third party collector.

Under the observation of the above 7 reviewed articles, we find that combinations of supply chain contracts for different links can achieve better reverse supply chain management. The corresponding matching and implementation deserve deeper exploration.

(2). Both single link and multiple links

Different from these papers analyzed before, Govindan and Popiuc (2014) examine an exceptional case comprising both the single-link and multiple-link situations in reverse logistics, which is defined as Situation D. The single link consists of a retailer and a manufacturer under which the retailer directly delivers returns to the manufacturer. While in the multiple-link situation, a third party collector is considered for buying returns from the retailer and then selling them to the manufacturer. In Govindan and Popiuc (2014), these two scenarios are both coordinated by a revenue sharing contract and the revenues are from remanufacturing and reselling activities conducted by the manufacturer.

Discussions

From the above review, we have Figure 2.3. In fact, the above analyses and Figure 2.3 indicate that in the reverse logistics literature, most supply chain contract papers focus on studying a single link with the focal point on coordination using a single contract (i.e., Situation A), which occupies 81% of the total reviewed papers. This is followed by the studies which focus on multiple links (10%).

Moreover, by further investigating Table 2.3 and Table 2.4, we can find that the hybrid contract and the two-part tariff contract are relatively more common under multiple links instead of the buyback and returns contract (i.e. the most popular one in the single link scenario). It is also obvious that the buyback and returns contract, as well as the two-part tariff contract, have a higher likelihood to be simultaneously utilized with another supply chain contract. For instance, a buyback and returns contract can be applied together with a two-part tariff contract or a risk sharing contract. Meanwhile, the combination of a wholesale pricing contract is quite common at the manufacturer level while the conjunction with a two-part tariff contract is more practical from the perspective of the retailer.

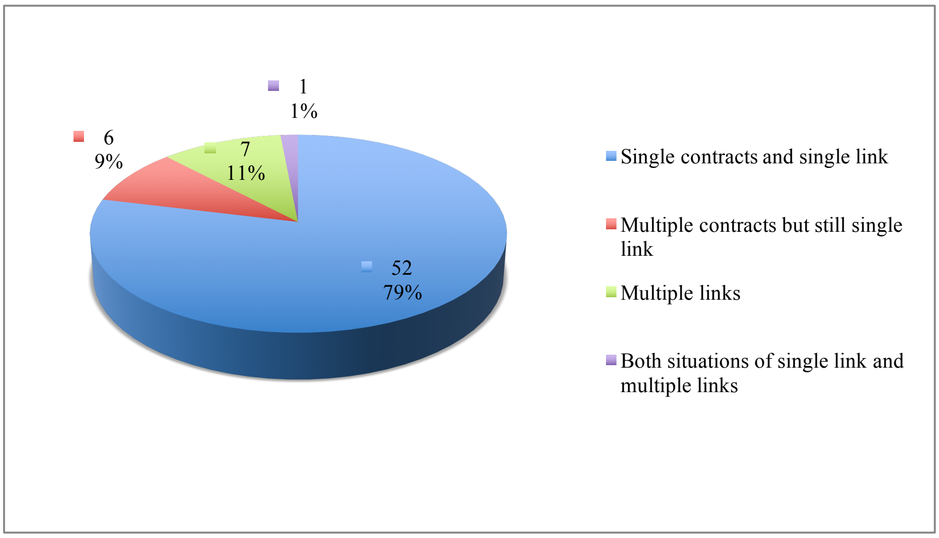

Figure 2.3 The number of supply chain contracts and involved links.

Table 2.3 The joint occurrence of supply chain contracts under the hybrid contracts setting

SC contracts	Involved links						
	M+S	M+R	M+D	M+T	R+D	R+RM	M+RM
Scenario 1		A buyback and returns contract + A two-part tariff contract					
Scenario 2[11]		A buyback and returns contract + A risk sharing contract					
Scenario 3	A wholesale pricing contract + A responsibility sharing contract						
Scenario 4		A wholesale pricing contract + A rebate contract + A buyback and returns contract					

[11] This scenario covers two papers.

Table 2.4 The joint occurrence of supply chain contracts under the multiple links setting

SC	Involved links								
contracts	**M+S**	**M+R**	**M+D**	**M+T**	**R+D**	**R+RM**	**M+RM**	**R+RM**	**R+RM**
Case 1		A two-part tariff contract + A hybrid contract		A two-part tariff contract + A hybrid contract[12]					
Case 2		A hybrid contract				A hybrid contract[13]			
Case 3		A two-part tariff contract					A two-part tariff contract	A two-part tariff contract	A two-part tariff contract
Case 4			A buyback and returns contract		A buyback and returns contract				
Case 5	A hybrid contract	A hybrid contract[14]							
Case 6		A wholesale pricing contract		A rebate contract					
Case 7								A wholesale pricing contract	A wholesale pricing contract

2.3.3 Review Based on Channel Leaderships

After exploring the application of supply chain contracts in different links in reverse supply chains, we explore the supply chain contracts with various channel leaderships in this section. The corresponding details are exhibited in Table 2.5 where the channel leaderships are divided into three subdivisions: 1) Single leader, 2) Nash bargaining and 3) Multiple scenarios. As a remark, the "multiple scenarios" group collects the papers in which either two or three kinds of channel leadership scenarios are investigated in each paper.

[12] It combines both a revenue sharing contract and a cost sharing contract.
[13] It combines both a revenue sharing contract and a two-part tariff contract.
[14] It combines both a profit sharing contract and a buyback and returns contract.

Table 2.5 Cross-analyses of supply chain contracts with various channel leaderships

Supply chain contracts	Channel leaderships						
	Single leader				Nash Bargaining	Multiple scenarios	Total
	M-led	R-led	RM-led	S-led			
1. Single link							
(1). Single contract							**53**
Buyback and returns contract	**10**	**3**	**1**	**1**	**3**	**0**	**18**
Revenue sharing contract	**7**	**1**	**0**	**0**	**0**	**0**	**8**
Wholesale pricing contract	**2**	**0**	**0**	**0**	**1**	**3**	**6**
Two-part tariff contract	**2**	**0**	**0**	**0**	**1**	**1**	**4**
Quantity discount contract	**1**	**0**	**1**	**0**	**0**	**0**	**2**
Risk sharing contract	**1**	**1**	**0**	**0**	**0**	**0**	**2**
Consignment contract	**1**	**0**	**0**	**0**	**0**	**0**	**1**
Rebate contract	**1**	**0**	**0**	**0**	**0**	**0**	**1**
Papers mentioning more than one contracts separately	**9**	**0**	**0**	**0**	**2**	**0**	**11**
(2). Hybrid contracts	**2**	**0**	**0**	**1**	**2**	**0**	**5**
Total	**36**	**5**	**2**	**2**	**9**	**4**	**58**
2. Multiple link	**3**	**0**	**1**	**0**	**2**	**1**	**7**
3. Both single link and multiple links	**1**	**0**	**0**	**0**	**0**	**0**	**1**
Total	**40**	**5**	**3**	**2**	**11**	**5**	**66**

Single Leader

From Figure 2.4 and Table 2.5, it is observed that supply chain coordination under the leadership of the manufacturer is the most widely analyzed scenario in reverse logistics. It comprises 36 articles under the single-link condition, 3 articles from the multiple-link scenario, and 1 article considering both the single link and multiple links. The reason for this distinct popularity is that few papers explore reverse logistics links without the participation of the manufacturer and the most frequently studied link is the manufacturer-retailer one (refer to Figure 2.5). Moreover, the popularity of the manufacturer-retailer link also explains why the retailer as the leader is the second prevailing single-leader situation based on Table 2.5. Apart from these two popular categories, there is also 2 papers investigating the leadership of the supplier in the supplier-manufacturer link, 3 papers exploring the leadership of the remanufacturer under the link between the remanufacturer and the third party collector, one examining the leadership of the remanufacturer in the remanufacturer-retailer link, and another one investigating the multiple-link scenario. Among these four kinds of single-leader conditions in reverse logistics, we first analyze the manufacturer-leader game since it is the most widely explored one.

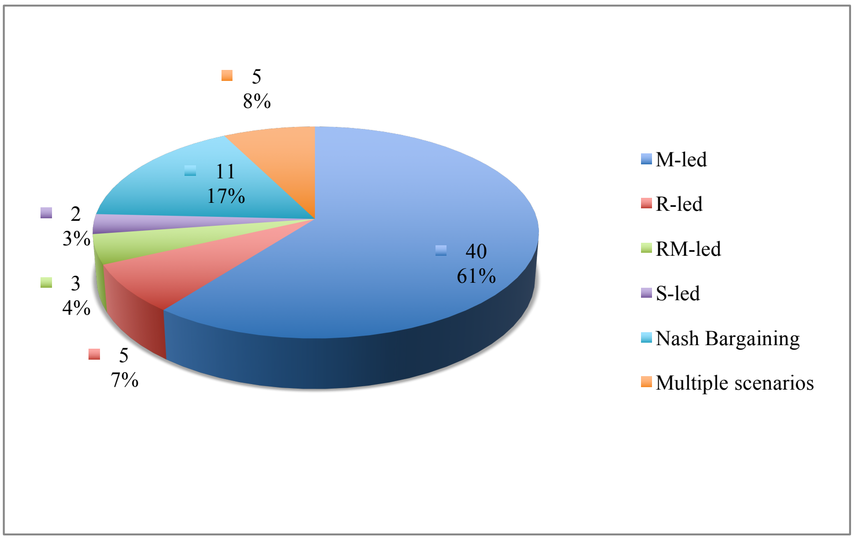

Figure 2.4 Distribution of different channel leadership situations.

(1). M-led scenario

As aforementioned, the manufacturer-leader scenario in reverse logistics covers 40 articles in total, the sources of which are exhibited in Figure 2.5. Under this scenario, we start by discussing the details of the manufacturer's leadership in various supply chain contracts under the manufacturer-retailer link, which includes 31 articles.

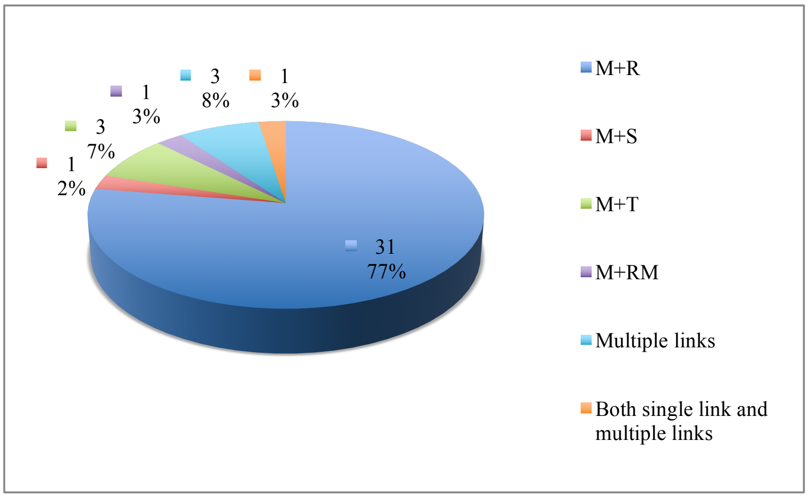

Figure 2.5 Manufacturer-led supply chain contracting under different links.

First of all, we examine the application of the buyback and returns contract. To be specific, Arcelus et al. (2011), Chen (2011), Lee and Rhee (2007) and Liu et al. (2014) assume that the manufacturer would buyback both leftover and customer-returned items. Besides, the manufacturer in Arcelus et al. (2011) only permits returns within a specified time period, the manufacturer in Chen (2011) requires a high level of information sharing about customer returns, the manufacturer in Lee and Rhee (2007) suffers from limited salvage capacities and the manufacturer in Liu et al. (2014) faces the influence of a refund-dependent demand on the number of the final returns. Li et al. (2012b) consider the case in which the manufacturer receives full information shared by the retailer and allows those off-season products to be returned. Xu et al. (2015) present a scenario where the manufacturer provides different credits for items returned at different time periods to motivate a timely return from the retailer. He et al. (2006) as well as Ohmura and Matsuo (2016) establish a model in which the risk preferences of the manufacturer are influential to the retailer's decision on order quantities. Yao et al. (2008) analyze the scenario when the manufacturer permits the return of unsold goods at the end of the selling season in order to overcome the negative impact of the price-sensitivity factors on the retailer's decisions. Wu (2013) discusses the impact of the buyback incentive offered by the manufacturer on the retailer's retail price and ordering quantity under a competing environment, which comprise two manufacturer–retailer supply chains.

Secondly, the revenue sharing contract is also popularly examined. There are seven related papers and they are examined below. Zeng (2013), Mafakheri and Nasiri (2013), Zou and Ye (2015), Ran et al. (2016) and Xie et al., (2017) hypothesize that the manufacturer would share its revenues from recycling, remanufacturing and reselling actions with the retailer to motivate the retailer to exert higher collection efforts for returns. Different from the above, Wu et al. (2015) consider the situation when the responsibility of collecting used items is assigned to the manufacturer and the contract is to guarantee the retailer's participation when facing remanufacturing cost disruptions. Besides, Giri et al., (2017) explore the utilization of a revenue sharing contract between multiple competing manufacturers and one single retailer under the leadership of the manufacturer. By investigating the pricing and quality decision making process under both the cases with and without consumer returns, the authors prove the performance of the revenue sharing contract.

Apart from the buyback and returns contract and the revenue sharing contract, other papers which study the use of single contracts in the manufacturer-led M-R link include Atasu et al. (2013), Huang et al. (2011), Hu et al. (2014), Hong et al. (2015) and Ferguson et al. (2006). In Atasu et al. (2013), the manufacturer provides a wholesale pricing contract to the retailer in order to lift order quantities and achieve higher sales volume as both of these two aspects relate to a higher probability of collecting more returns. Hu et al. (2014) assume that the manufacturer applies a consignment contract aiming at mitigating the consumer misfit returns behaviors. Hong et al. (2015) focus on a situation where the manufacturer exerts its influence on the retailer, via a two-part tariff contract, to endeavor more on local advertising for collecting returns. Besides, both Ferguson et al. (2006) and Huang et al. (2011) explore the case when the manufacturer provides a contract to the retailer in order to decrease the false failure returns' amount, although Huang et al. (2011) consider the case when the manufacturer provides a quantity discount contract while Ferguson et al. (2006) analyze the scenario where the manufacturer proposes a target rebate contract.

In addition, seven articles considering the comparison of different contracts have studied the manufacturer-led game in the manufacturer-retailer link in reverse supply chains. Xiao et al. (2010) investigate the different effectiveness of the buyback and returns contract and the markdown contract in ensuring the manufacturer's profits. Ruiz-Benitez and Muriel (2014) compare the buyback and returns contract and the wholesale pricing contract to figure out a more appropriate way to allocate the burden of leftover from the manufacturer's perspective. Huang et al. (2014) study the performance of the buyback and returns contract and the rebate contract in increasing the retailer's order quantity when there is a secondary market. De Giovanni (2014) examines the revenue sharing contract and the wholesale pricing contract to simulate as much returns' residual value as possible for the manufacturer. Zhang et al. (2014a) conduct the comparison study between a two-part tariff contract and a collection effort requirement contract. They discuss how the manufacturer determines the more efficient one with respect to the given varied collection effort of the retailer. Yoo et al. (2015) examine how various contracts provided by the manufacturer influence the retailer's decisions by comparing among the wholesale pricing contract, the buyback and returns contract and the quantity discount contract. Song et al. (2008) explore the optimal retail decisions and the optimal profit allocation under the contracts of wholesale pricing, buyback and returns, and consignment, respectively, when the retail demand presents a multiplicative form (price-sensitive and stochastic). Then different from the single-contract scenario we examined above, Savaskan and Van Wassenhove (2006) analyze how a hybrid contract, which is based on a buyback and returns contract and a two-part tariff contract, helps a manufacturer to guarantee two retailers' collection effort since he can incorporate remanufacturing of used items into the original production system. Chiu et al. (2011) design a hybrid contract combining the wholesale pricing contract, the rebate contract and the buyback and returns contract, under which the manufacturer has the absolute power to decide all contract variables like the wholesale price, the buyback price, target sales level and rebate value.

After discussing the impact of manufacturer's leadership under the M-R link, we explore other links in reverse logistics that are also led by the manufacturer in the selected literature. Hong and Yeh (2012), Kaya (2010) and Hu et al., (2016) explore the case when the manufacturer interacts with the third party collector to collect consumer returns, although Kaya (2010) investigates the performance of a two-part tariff contract in collecting more returns for remanufacturing while Hong and Yeh (2012) focus on maximizing the profit of the manufacturer by efficiently handling the collected items under a wholesale pricing contract and Hu et al., (2016) examine the performance of five different supply chain contracts in increasing the collection quantity of consumer returned items as well as the profit of the reverse supply chain. He (2015) analyzes a manufacturer-supplier link where the manufacturer utilizes its power to motivate the supplier to acquire more returns in the recycle channel under a risk-sharing contract. Chen and Chang (2014) study the link between the manufacturer and the remanufacturer under the assumption that the manufacturer could control customers' behaviors. The authors aim to identify the way to attain a more reasonable profit allocation, regarding the manufacturer's dominant power, by comparing the revenue sharing contract and the wholesale pricing contract.

The manufacturer-led scenario in reverse logistics has also been explored in the case involving multiple links. For example, Bhattacharya et al. (2006) examine both the manufacturer-remanufacturer link and the manufacturer-retailer link, under which two different two-part tariff contracts are applied to encourage the cooperation of the retailer and the remanufacturer so as to guarantee the manufacturer's efficiency gains. Yan and Sun (2012) assume that the manufacturer expects a high effort level for collecting returns and therefore provides a wholesale pricing contract and a target rebate-punish contract to manage the retailer-manufacturer link and the manufacturer-the third party collector link, respectively. Zhang and Ren (2016) consider a network controlled by a manufacturer, including a remanufacturer and a retailer, and the manufacturer would utilize its power to influence the other members by deciding the wholesale price charged to the retailer and the patent licensing fees charged to the remanufacturer. Lastly, Govindan and Popiuc (2014) discuss both the single-link and multiple-link structures, under both of which the manufacturer provides a revenue sharing contract to the other supply chain player(s) aiming at stimulating more returns for the remanufacturing process.

(2). R-led scenario

Compared to the manufacturer-led configuration, the popularity of the retailer-led game under the reverse logistics is relatively low. We first analyze the situation concerning the retailer-manufacturer link. Jeong (2012) and Matsui (2010) both find that the information about customers' product expectations and market demand, which is entirely possessed by the retailer, is quite crucial to the manufacturer and therefore, this contributes to the leadership of the retailer when cooperating with the manufacturer under the buyback and returns contract. The focal points of these two papers, however, are quite different. To be specific, Jeong (2012) studies the collection and transmission of this piece of information while Matsui (2010) mainly explores the influence of the demand uncertainty. He and Zhang (2010) consider a secondary market, which is employed by the manufacturer to acquire or dispose products. They argue that the retailer would share the yield randomness with the manufacturer to encourage a higher production performance at the manufacturer's side, in the presence of the secondary market.

For other links, under the retailer-led case, we have a few more papers. Huang et al. (2015) develop a model where the retailer offers a buyback and returns contract to the third party collector in order to acquire enough consumer returns for further remanufacturing. Weraikat et al. (2016) explore the link between the retailer and the third party collector under a revenue sharing contract, in which the third party collector is required to meet a target of collected leftover set by the retailer.

(3). Other channel leadership scenario

One relatively under-explored channel leadership situation in reverse logistics is the one led by the remanufacturer as only three papers study such situation. Gu and Tagaras (2014) investigate a structure comprising a third party collector and a remanufacturer where the remanufacturer would only buy back those remanufacturable ones and the proposed buyback and returns contract is to guarantee the remanufacturer's profit by considering the high uncertainty in returns' quality conditions. Jena and Sarmah (2016) design a network consisting of two competitive remanufacturers and one common retailer. The authors assume that the retailer faces an uncertain demand of remanufactured items. Under this network, the remanufacturers offer a quantity discount contract to the retailer to motivate a larger order quantity and a lower retail price to ensure the remanufacturers' market share for their remanufactured products. Li et al., (2017) compare the performance of four different reverse supply chain coordination structures, which are all based on the objective of maximizing both the profit and the social benefit. The authors analyze the strategic influence of the market demand of remanufactured products as well as the utilization ratio of consumer returns, from the aspects of the channel profit, the recycle quantity of the collected items and the final retail prices.

Similarly, the supplier-led scenario is also under-explored. Hou et al. (2010) and Jacobs and Subramanian (2012) explore the coordination challenge between the supplier and the manufacturer in reverse logistics. Hou et al. (2010) study a buyback and returns contact between a manufacturer and its backup supplier considering its main supplier's supply uncertainty and such structure also gives the dominant power to the backup supplier since it can help the manufacturer mitigate the risk from the main supplier. Jacobs and Subramanian (2012) propose a hybrid contract to share the responsibility of product recovery, under which, apart from the supplier, the manufacturer is also responsible for meeting the collection and recycling targets set by the legal regulation.

Nash Bargaining

In some supply chains, decisions are made under bargaining and there are no clear leaders. We hence have the Nash bargaining scenario. In fact, under Nash Bargaining, the equilibrium choices of related parameters depend on relative power of the participated members. In this domain, Bose and Anand (2007), Chen and Bell (2011), Dobos et al. (2013) and Zhang et al. (2015) study the retailer-manufacturer link. Among them, Dobos et al. (2013) focus on the two-part tariff contract while Chen and Bell (2011) as well as Zhang et al. (2015) investigate a buyback and return contract under the influence of consumers' satisfaction or environmental awareness. At the same time, Bose and Anand (2007) examine the efficiency of a buyback and return contract when the wholesale price is exogenous. Different from the above, Hong et al. (2008) discuss the material flow allocation and pricing decisions in the link between the remanufacturer and the third party collector based on the application of a wholesale pricing contract. Furthermore, Zhao and Zhu (2015) explore the retailer-remanufacturer game in which both a revenue sharing contract and a wholesale pricing contract are examined about their effectiveness in stimulating more returns of used items from the retailer. Su (2009) analyzes the impact of full customer returns policies on channel coordination by comparing the performance of a buyback and returns contract with a rebate contract under the retailer-remanufacturer link. At the same time, both Chen et al. (2006) and Shi (2006) discuss the management of the link between the retailer and the remanufacturer via a hybrid contract (i.e., by combining a buyback and return contract with a risk sharing contract), but with different focal points. To be specific, Shi (2006) focuses on the overstock risk while Chen et al. (2006) consider both the overproduction and overstock risk. In addition to the above papers that are based on the single-link scenario, Arshinder et al. (2009) explore the mutual decision-making process on the decision variables under the buyback and return contracts in both the manufacturer-distributor link and the distributor-retailer link, which help all members to achieve more profits by sharing risks and rewards. Ding and Chen (2008) concentrate on negotiation of the parameter design in the final hybrid contracts, such as the return price and the profit allocation ratios, under a three-level supply chain network. This network consists of a supplier, a manufacturer and a retailer.

Multiple Scenarios

We define the multiple scenarios in which different leaderships with/without bargaining are explored. In our review, we have identified a few in which 2 articles examine the manufacturer-retailer link, 1 paper focuses on the manufacturer-supplier link, 1 paper explores the remanufacturer-third party collector link and 1 paper involves multiple links in the reverse supply chain. We review these papers in the following.

Gao et al. (2016) study the impacts of channel power configurations on participants' profits and their collection effort of returns by comparing the manufacturer-led, the retailer-led and the vertical Nash scenarios under the coordination by a two-part tariff contract. Li et al. (2012a) analyze the different performance of the wholesale pricing contract, referring to the return quantities and profits for both members, under both the retailer-led and the Nash bargaining cases. As a remark, these 2 papers are based on the link between the manufacturer and the retailer.

Li and Li (2016) discuss the Nash bargaining and the supplier-led cases using the wholesale pricing contract. They aim to reveal the more efficient one in a competitive environment. Ye et al. (2016) measure the efficiency loss of reverse logistics by comparing three competitive structures with the implementation of a wholesale pricing contract. Both the remanufacturer Stackelberg and the third party collector Stackelberg scenarios are analyzed. Choi et al. (2013a) explore when higher effectiveness in collecting used products and better performance of the whole reverse supply chain could be attained by considering three different kinds of channel leaderships. They further propose effective coordination mechanisms which include the two-part tariff contract and the revenue-cost sharing contract.

Discussions

Based on the discussion above, we have Table 2.6, which indicates the most popular supply chain contract under different channel leaderships as well as the performance of these leaderships. It can be observed that the buyback and returns contract is always the most prevailing supply chain contract in the field of reverse logistics regardless of the channel leaderships. As for the performance of various channel leaderships, after deeply investigating the selected papers, we find that the R-led game has the best performance in guaranteeing the collecting effort for returns and in the meantime, the M-led structure indicates the highest feasibility when exploring multiple supply chain contracts and multiple links in reverse logistics.

Table 2.6 Results analysis of channel leaderships

Category	Channel leaderships			
	M-led	R-led	RM-led	S-led
Most popular supply chain contract	Buyback and returns contract	Buyback and returns contract	Both buyback and returns contract and quantity discount contract	Buyback and returns contract
Positive effect on collection effort		1st	2nd	
Feasibility in multiple contracts	1st			
Feasibility in multiple links	1st			

2.3.4 Concluding Remarks

From the above review, it can be seen that the manufacturer-led case is the most common leadership scenario in the existing literature on supply contracting with consumer returns whereas the remaining channel leadership scenarios, such as the retailer-led one, are still under-explored. However, given the growing power of retailers and the existence of many retail programs such as mass customization nowadays (Chen and Xiao, 2009; Choi, 2013; Huang et al., 2002; Liu et al., 2012; Wang and Liu, 2007; Xiao et al., 2014; Yue et al., 2006), the retailer-led scenarios deserve further investigations. Therefore, later parts of this thesis fill this research gap by conducting deep investigation on a fashion mass customization supply chain with consumer returns, which is led by the fashion retailer.

In addition, according to the analysis in Section 2.3.2, the buyback and returns contract, the revenue sharing contract, the wholesale pricing contract and the two-part tariff contract have already been relatively well-explored in the existing literature but not the others. We thus also examine the application of other under-explored supply chain contracts like the hybrid contracts in the analytical models established in the following sections.

2.4 Mass Customization Supply Chain Management

The fashion market nowadays is widely acknowledged to be characterized by the diverse and everchanging customer needs and preferences, as well as the fierce competition. These characteristics enforce the fashion firms to enhance their entire responsiveness to the target market and improve the flexibility of adapting to the dynamic industrial environment, which consequently contributes to the popularity of MC in the fashion industry. In the meantime, as a strategy based on both the stock-driven environment (i.e., inventory preparation and management for the un-customized products) and the order-driven environment (i.e., inventory preparation and further process on those customized items), the MC scheme has also attracted plenty of attention from various researchers. For instance, topics on both the aspects of regular inventory management, like the postponement strategy and the management on product quality as well as product variety, and leftover inventory management such as the consumer returns in MC, have been extensively studied.

First of all, for the product quality and product variety management in MC, Ni et al., (2007), Zhao and Fan (2007) and Kuo (2013) proposed various approaches to improve the quality of MC products in the supply chain. For example, Ni et al., (2007) examined the product quality issue from the perspective of supplier selection and developed a quality-based system for supplier selection in the MC program. In this quality-based system, customer requirement, product usage patterns as well as frequent fault patterns were chosen as major criteria when examining the performance of different suppliers, and decision-support techniques like data-mining and extended quality function deployment were applied. Similarly, the quality function deployment technology is also recommended in Kuo (2013) by introducing it into the software component design process in MC, which can substantially enhance the quality and reusability of MC products. Different from above, Zhao and Fan (2007) investigated the quality management problem from a systematic level and proposed a reformative enterprise resource planning (ERP) system, which is based on the integration of the quality function deployment methodology, for the MC environment. The authors proved its unique efficiency in enhancing the quality of MC items and lowering relevant costs by comparing with the traditional ERP systems. Then for product variety management in MC, Salvador and Forza (2004), Jiao et al., (2007), Alptekinoğlu and Corbett (2008), Forza and Salvador (2008), Kang and Hong (2009) and Daaboul et al., (2011) all have deeply explored the strategic decisions on the variety level of MC products.

Apart from product quality and product variety, there are also some papers investigating the postponement strategy in MC, which refers to the deliberate delay on some MC processes like the production process. Among these papers, Su et al. (2005) studied the implementations of both time postponement and form postponement in MC, and their respective performance in costs control as well as time control were evaluated and compared. In Su et al. (2005), the influences brought by external factors like the number of products and interest rates were also analyzed. Another similar paper is Shao and Ji (2008) which also conducted comparisons between the applications of different postponement strategies in MC, under the consideration of the service time guarantees in MC. The authors aimed at studying the most influential factors in MC performance and deriving a most appropriate postponement strategy. Differently, both Hsuan-Mikkola and Skjøtt-Larsen (2004) and Liao et al., (2013) explored the relationship between the postponement practice and the efficiency of product modularity design in MC, and the MC capabilities were also discussed.

Besides, given the existence of consumer returns policy and the popularity of the online platform in MC, there are also quite a few papers investigating the management on consumer returns in MC, and we introduce them as follows. Liu et al. (2012) explored the consumer returns management problem under the influence of supply chain players' risk attitudes as well as the demand and return uncertainty, and the optimal decisions on the pricing and level of modularity were studied. Choi (2013) examined the application of a return service charge policy in MC, which contained an additional fee charged to the related consumers for the abuse of the return right. The author considered both the scenarios of risk-neutral MC brands and the risk-averse ones. Choi et al., (2013b) conducted analytical analysis on different performance of a full refund policy and a no refund policy in managing the consumer returns when the fashion MC program suffers from both the demand uncertainty and return uncertainty. Li et al. (2016) developed both a competitive and a cooperative market environment and discussed the respective effects of the consumer return policy, the modularity level of MC as well as the production lead time and pricing factors on the MC scheme under different market environments.

In addition, as can be observed from above, although there are various papers analyzing the supply chain management issue on an MC program, none of them has examined the salvage value of the unsold products and consumer returned items. Therefore, in later chapters of this thesis, we explore the salvage values of these two kinds of leftovers in our analytical models and propose several system enhancement measures to help improve the final performance of MC schemes.

2.5 Summary

In this chapter, plenty of literature related to the topics of consumer returns in the supply chains, supply contracting in fashion supply chains, supply contracting with consumer returns, as well as the mass customization supply chains, has been reviewed. It is found that although there are many papers exploring these four different topics, none of them simultaneously investigates these aspects together.

In addition, according to the discussion conducted above, several research gaps have also been identified: (i) In supply chain management, the salvage values of consumer returns and their influence on the optimal ordering quantities as well as supply chain coordination mechanisms are still under-explored; (ii) Under the topic of supply contracting in fashion supply chains, the existence of consumer returns as well as unsold items on the supply contracting issue are neglected by the existing literature when examining the effects brought by information updating; (iii) In the field of supply contracting with consumer returns, the manufacturer-led case has already been widely discussed whereas the remaining channel leadership scenarios, such as the retailer-led one, are still under-explored; (iv) Single traditional supply chain contracts, like the buyback and returns contract, the revenue sharing contract, the wholesale pricing contract as well as the two-part tariff contract, are very common coordination mechanisms reported in the literature, but it is not the case for other supply chain contracts like the hybrid contracts; (v) Although there are various papers analyzing the supply chain management issue on an MC program, none of them has examined the role played by the salvage values of the unsold inventories and consumer returned products.

3. Case Studies: Consumer Returns in Mass Customization Programs in the Fashion Industry

MC, as a strategy efficient in collecting related customer data and satisfying target consumers, has already attracted a large volume of attentions from various fashion companies. Therefore, given the popularity of MC in the fashion industry and the existence of consumer returns policies, specific details of consumer return policies in two representative MC brands are analyzed in this chapter.

3.1 Case 1: NIKE

3.1.1 NIKEiD

In fashion industry, Nike is widely known as one of the worldwide leading sports footwear and apparel brands, which is also one of the most famous pioneers in MC schemes. With NIKEiD[15], Nike's MC program launched in 1999 (Baena, 2016), consumers can flexibly customize a wide coverage of style and fit of the most popular pre-existing shoes provided by Nike into their own tastes and preferences, which can be done either through the online platform or NIKEiD studios with some limitations.

The product range of NIKEiD covers customized items for men, women, boys and girls (see Figure 3.1 captured from Nike's official website), and includes various collections like NIKEiD new releases (e.g., Nike Metcon 4 iD and Nike Air Force 1 Low Premium iD in Figure 3.2), NIKEiD NBA collection (e.g., Nike Air Force 1 High Premium iD in Figure 3.3), NIKEiD Pendleton collection (e.g., Nike Cortez Premium iD and Nike Air Force 1 Mid Premium iD in Figure 3.4), as well as others.

[15] Notice that Nike's official website is regarded as the major source of the information utilized in this section, and more information about NIKEiD can be found in Nike's official website https://www.nike.com/hk/en_gb/c/nikeid.

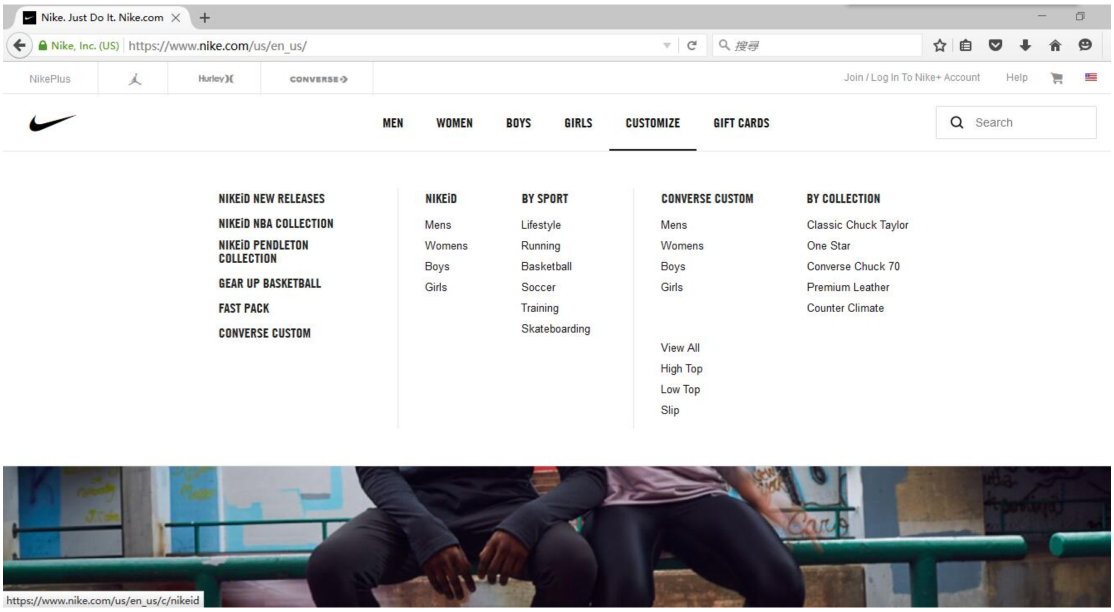

Figure 3.1 A brief coverage of NIKEiD

(captured from Nike's official website on Dec 28, 2017,

https://store.nike.com/us/en_us/pw/custom-pendleton-and-leather-styles/xif)

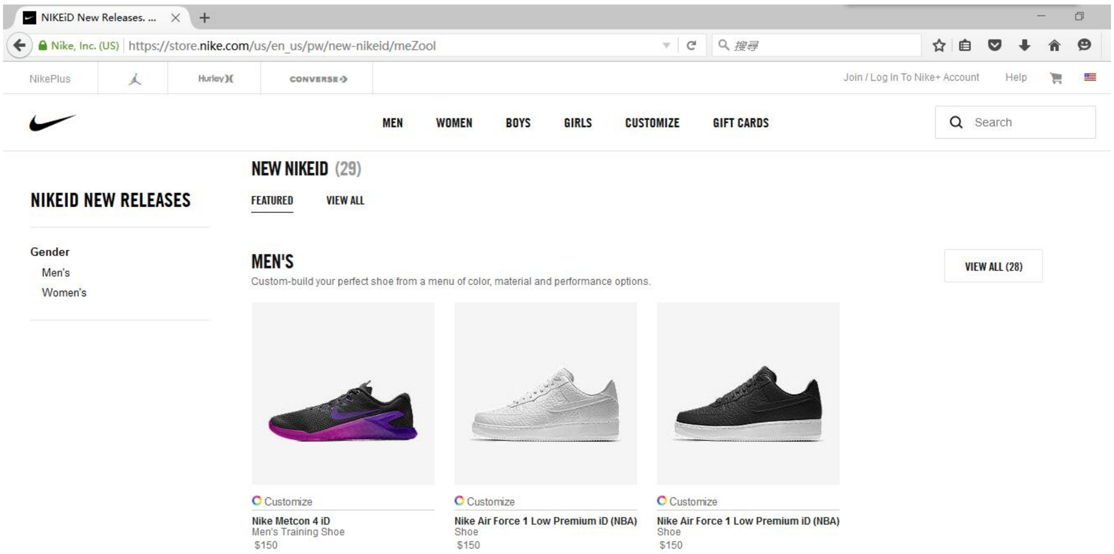

Figure 3.2 Examples of NIKEiD New Releases

(captured from Nike's official website on Dec 28, 2017,

https://store.nike.com/us/en_us/pw/new-nikeid/meZool)

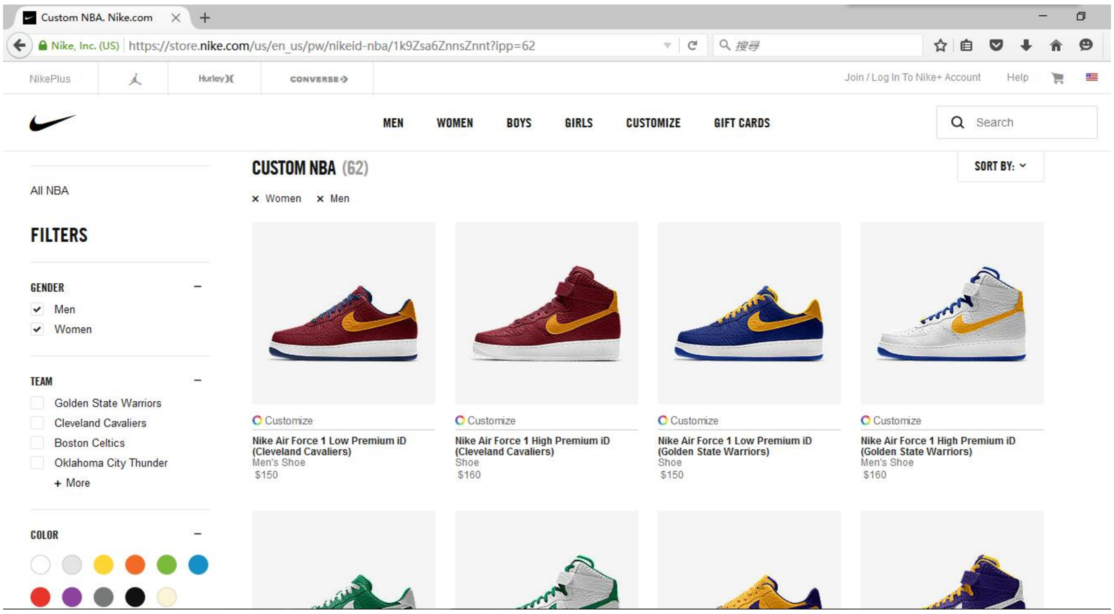

Figure 3.3 Examples of NIKEiD NBA collection

(captured from Nike's official website on Dec 28, 2017, https://store.nike.com/us/en_us/pw/nikeid-nba/1k9Zsa6ZnnsZnnt?ipp=62)

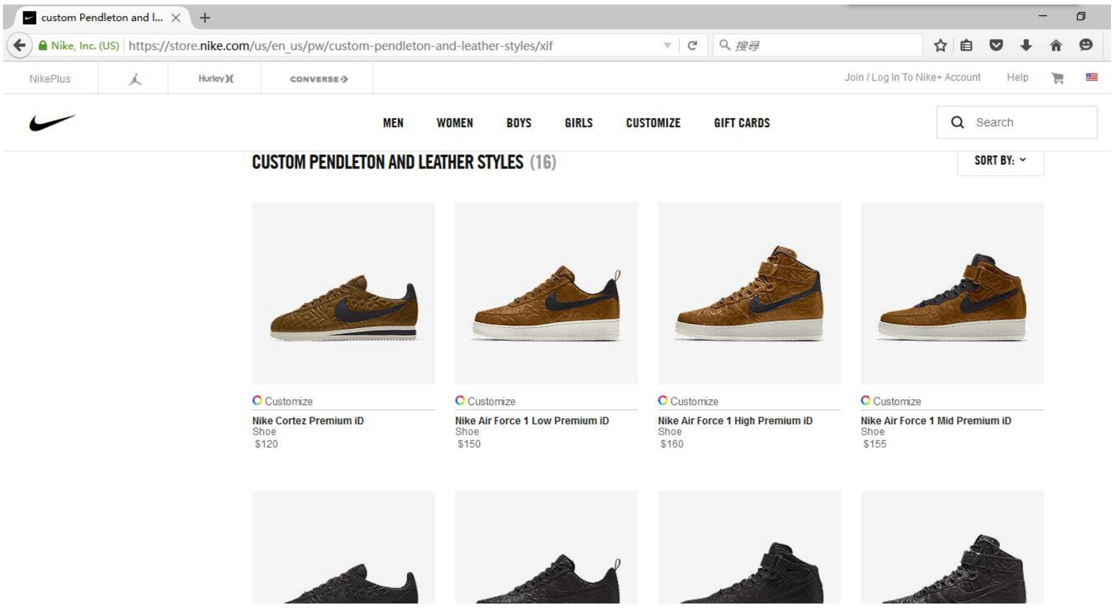

Figure 3.4 Examples of NIKEiD Pendleton collection

(captured from Nike's official website on Dec 28, 2017, https://store.nike.com/us/en_us/pw/custom-pendleton-and-leather-styles/xif)

As for the limitations on the provided items, it refer to some pre-determined customization options like the set choices of color schemes, product patterns, materials, and some shoe parts like the base, vamp, tip on their chosen shoes.[16] Apart from changing the main elements, consumers can also replace the Nike Air logo by adding some novel texts onto the tongue, side or the backheel tab of their shoes (it depends on the type of shoes), if they wish.

3.1.2 NIKEiD Return Policy

As is released on Nike's official website (refer to Figure 3.5.a and Figure 3.5.b), "NIKEiD orders can be returned for any reason within 30 days of the shipping date. After 30 days, NIKEiD orders can be returned if the product is unworn or is defective. Some restrictions apply." That is, within 30 days of the shipping date, consumers can unconditionally return the MC products based on any reasons, which include manufacturing defects, quality defects or wrong size, or even their dislike on the products. While if after 30 days, only unworn or defective MC products can be returned to Nike with some restrictions.

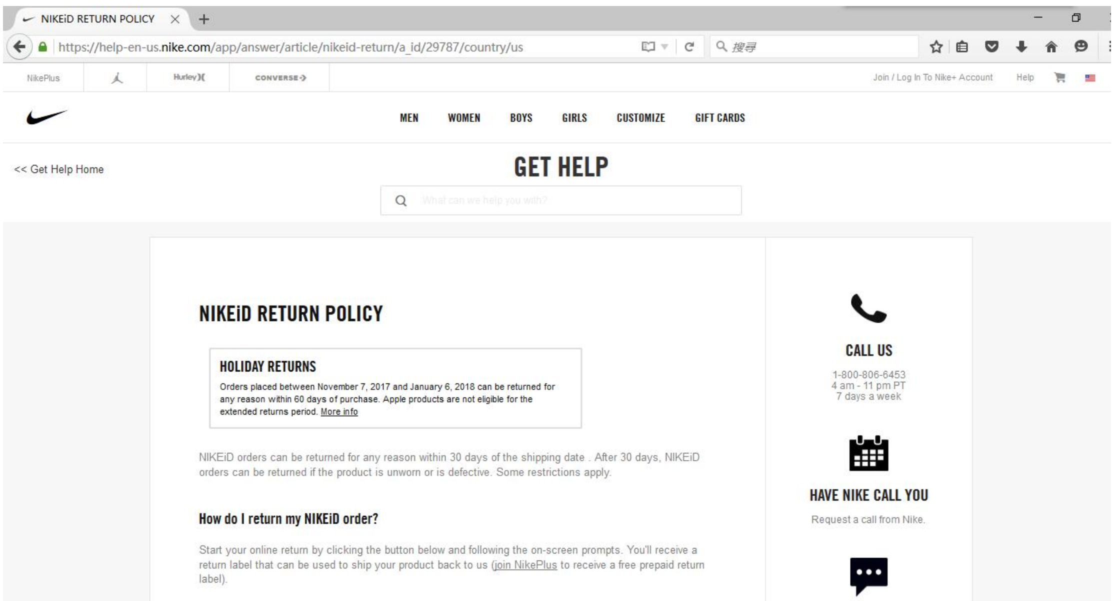

Figure 3.5.a Specific terms of NIKEiD Return Policy

(captured from Nike's official website on Dec 28, 2017, https://help-en-us.nike.com/app/answer/article/nikeid-return/a_id/29787/country/us)

[16] Notice that, NIKEiD does not require the customers to design the shoes by themselves, but instead, it refers to buy a selection of pre-made designs.

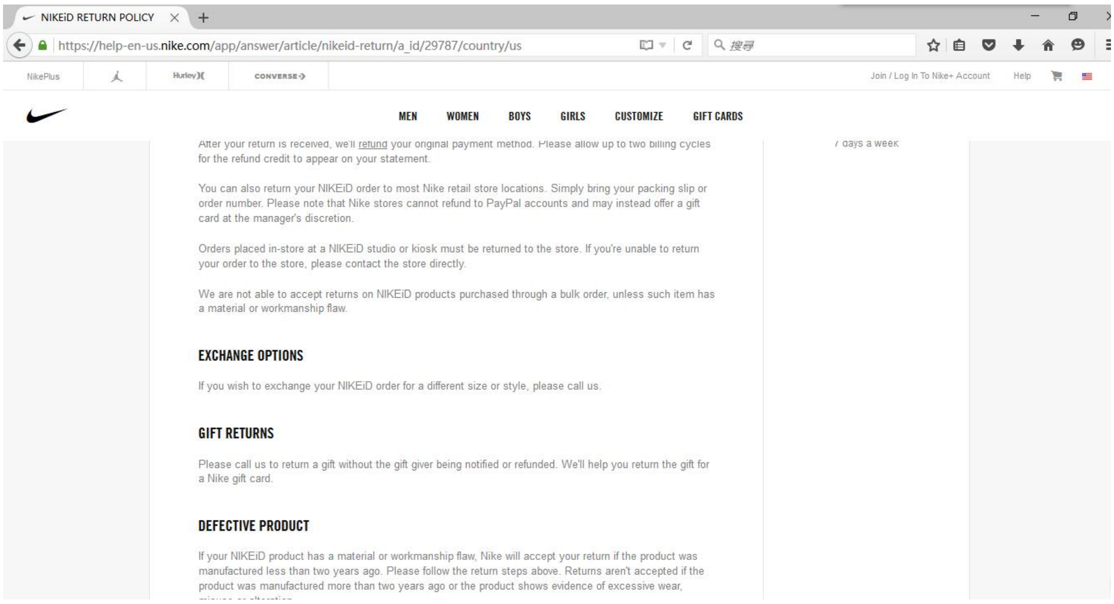

Figure 3.5.b Specific terms of NIKEiD Return Policy

(captured from Nike's official website on Dec 28, 2017, https://help-en-us.nike.com/app/answer/article/nikeid-return/a_id/29787/country/us)

For all unconditional consumer returns, full refund is guaranteed and multiple ways are provided for consumers to return their ordered NIKEiD products. Specifically, for customers who have ordered their products on the online platform, they can either choose online return through its official website (https://help-en-us.nike.com/app/answer/article/nikeid-return/a_id/29787/country/us) or return their NIKEiD orders directly to many physical retail stores of Nike. However, "orders placed in-store at a NIKEiD studio or kiosk must be returned to the store." In addition, NIKEiD products which are purchased through a bulk order (i.e., not an individual order) cannot be returned to Nike useless there is some default flaw on the customized items, like the material and workmanship flaw. Notice that, the flaw does not include those excessive wear or misuse related problems. In fact, for the NIKEiD products with flaw, i.e., the defective MC products, Nike even promises to accept consumer returns for those products which were shipped more than 30 days ago as long as it was manufactured less than two years ago.

Besides, under NIKEiD, the MC return service differs in different market segments. For example, for registered Nike members, the return service is free of charge while for the consumers who purchase NIKEiD product as a guest, they have to bear the return shipping fees by themselves (Choi, 2013).

3.1.3 NIKEiD Supply Chain

Different from the traditional channel of selling products through the upstream retailers, Nike shortens its supply chain with the NIKEiD scheme, under which the MC items are directly sold to the consumers without any additional middlemen (i.e., the retailers). Consequently, it only takes Nike 3-5 weeks to deliver the MC products to the consumers as announced in its official website.

Apart from this, the NIKEiD scheme also enables Nike to reduce the costs resulted from leftover inventories, under which the MC items are produced in direct response to market demand as well as consumer preferences, and the basic items are prepared with flexible combinations for further utilization (based on updated information). This consequently releases Nike from the heavy forecasting workload on the market demand of each SKU, colour and size of the seasonable products, and helps Nike achieve an exponential increase in the number of SKUs with a very limited increment in the inventory quantity as well as raw material costs.

Besides, in order to achieve a cost-effective outcome, Nike outsources the entire production and manufacturing process of its MC program, i.e., outsources everything from the initial parts' and elements' preparation to the final MC items' production and customization, to the third parties through supply chain contracts, e.g., to its partners in Asia (Pollard et al., 2016).

3.2 Case 2: Shoes of Prey

3.2.1 Shoes of Prey

Another representative example of MC schemes is Shoes of Prey, a US-based MC retailer famous for its online MC services in women's shoes provided to worldwide consumers since 2009. It had stated to have a transaction volume of more than 6 million mass customized shoes since 2016 (refer to its 2016 end-of-year report). According to the estimation of Intelligence platform Owler, the revenue of Shoes of Prey even has hit $2.5 million last year.

Under Shoes of Prey's MC program, consumers can easily customize their shoes by visiting the official website via computer, or smartphone or even tablet. For instance, consumers can firstly choose their basic shoes from five general shoe types, referring to heels, flats, boots, sandals and sneakers (see Figure 3.6.a for more information). Then based on the chosen type, various designs for different shoe parts like the material, toe, heel, heights, strap and decorations are offered (see Figure 3.6.b). In the meantime, consumers can also enjoy a wide range of color and leather options, such as knit, suede and silk. Besides, similar to other MC brands, the possible design of MC shoes provided by Shoes of Prey is also with some restrictions so as to assure that all final combinations of different modules (e.g., the materials and other key elements) chosen by the consumers are in fact practical and feasible to be produced.

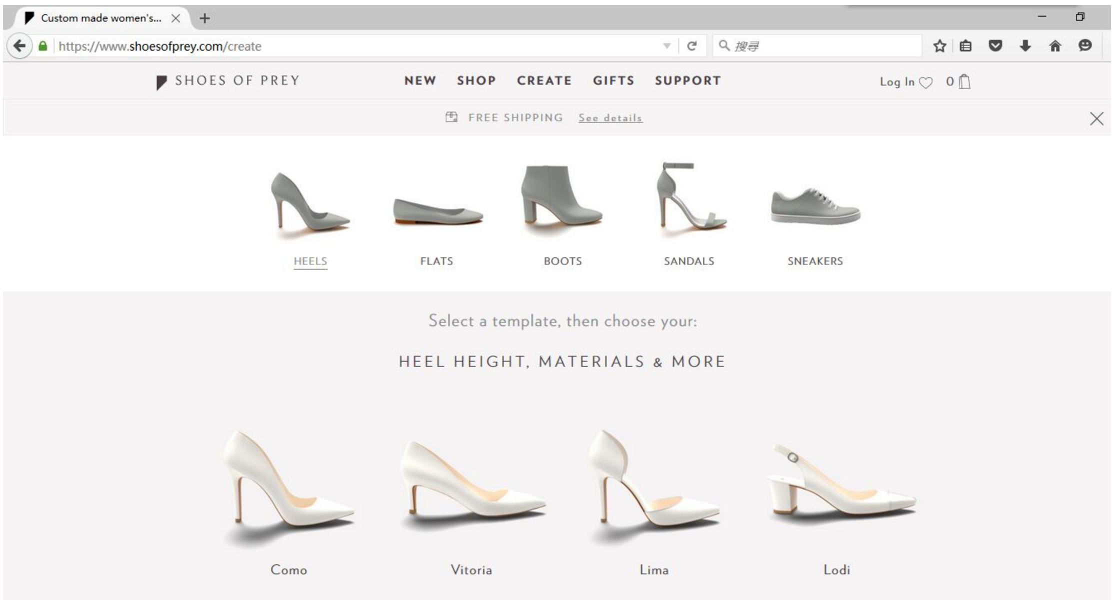

Figure 3.6.a Online MC design platform of Shoes of Prey

(captured from Shoes of Prey's official website on Dec 29, 2017, https://www.shoesofprey.com/create)

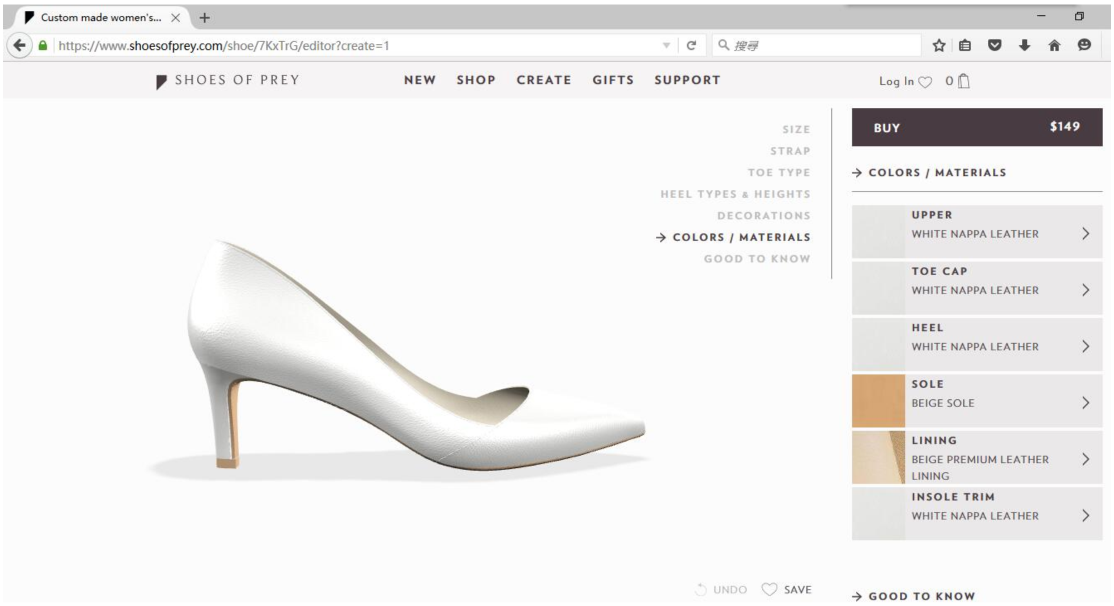

Figure 3.6.b Online MC design platform of Shoes of Prey

(captured from Shoes of Prey's official website on Dec 29, 2017, https://www.shoesofprey.com/shoe/7KxTrG/editor?create=1)

3.2.2 Shoes of Prey's Return Policy

As is claimed by Shoes of Prey on its official link[17] (refer to Figure 3.7.a and Figure 3.7.b below), consumers are guaranteed with the unconditional consumer returns policy with "100 percent of the price you paid", which is available for any MC products "in an unworn condition within 365 days of receiving them." Properly, for example, if the consumers find that the customized shoes do not fit or meet their expectations, they can directly return the products to Shoes of Prey and simultaneously enjoy the additional remake service provided by Shoes of Prey, which is free of charge. Alternatively, consumers can also have their shoes repaired or adjusted by some stores who offer professional repair services in their cities, and the relevant costs will be covered by Shoes of Prey. Then for the case of damaged items (i.e., faulty ones)[18], which may be resulted from the manufacturing or delivering activities, as can be seen from Figure 3.7.b, consumers can also return

[17] https://www.shoesofprey.com/content/returns.html.

[18] Notice that according to the statement of Shoes of Prey, products damaged from wear and tear are not considered in this case.

them to Shoes of Prey for further repair or even replace them with another one which has exactly the same design required by them.

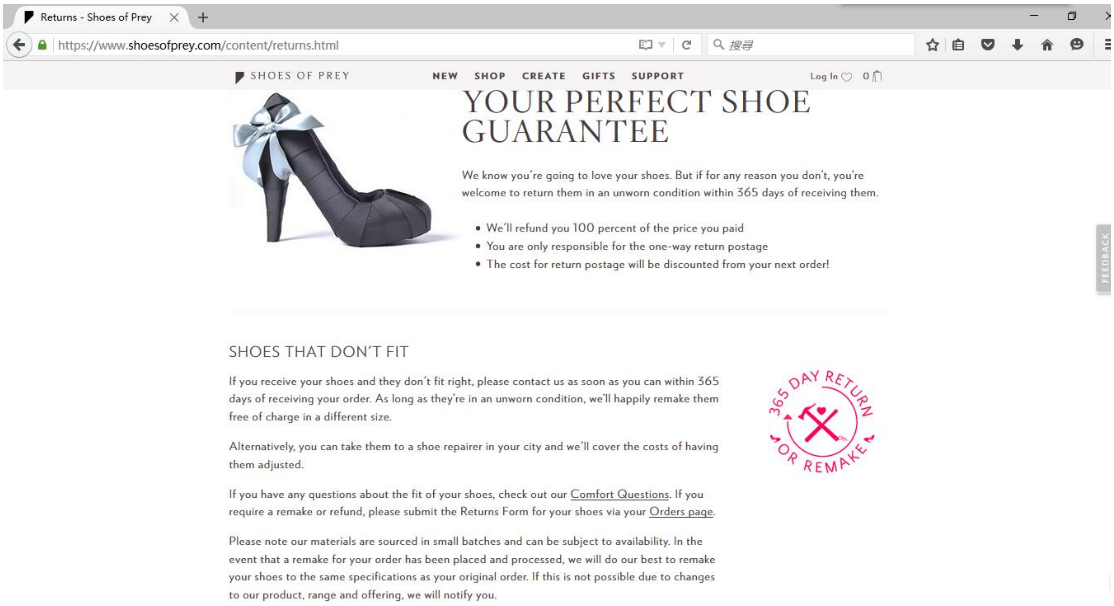

Figure 3.7.a Specific terms of Shoes of Prey's Return Policy

(captured from Nike's official website on Dec 29, 2017, https://www.shoesofprey.com/content/returns.html)

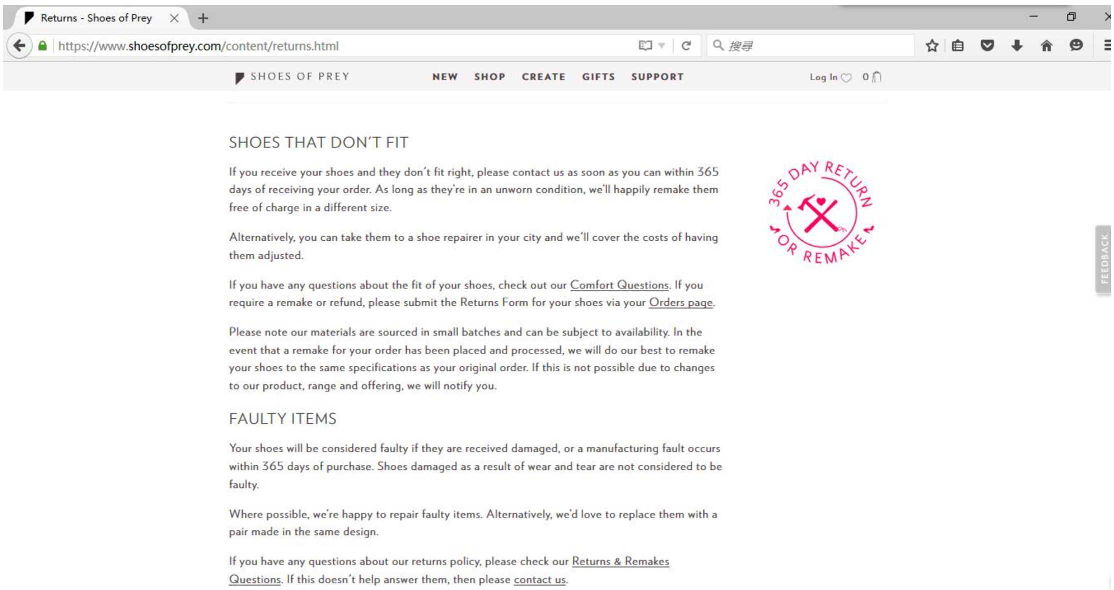

Figure 3.7.b Specific terms of Shoes of Prey's Return Policy

(captured from Nike's official website on Dec 29, 2017, https://www.shoesofprey.com/content/returns.html)

Note that, for the post-sale service of the MC products which includes a return process, the only responsibility of the consumers is the one-way return postage, which will be automatically discounted from the next order of the consumer.

3.2.3 Shoes of Prey's Supply chain

For the leadtime from initial production to the final delivery, it usually takes Shoes of Prey 2 weeks to process and finish all related activities.[19] In the meantime, a choice of Express Service is also provided to consumers "in the US and other select countries" together with an additional fee.

For the production and manufacturing activities, similar to Nike, Shoes of Prey also outsources them to external third parities, and the preference of the third parities selection is given to the manufacturer who provides production service of shoes for multiple retailers and has the capability of tackling the complex MC production requirements emphasized by Shoes of Prey (Altonen, 2011). These requirements are passed by Shoes of Prey after receiving MC orders from consumers, which then forwards the whole manufacturing activities. Besides, before finally sending to the consumers, individual quality control is performed on each MC shoe received from the manufacturer.

3.3 Summary

Based on the discussion above as well as the findings shown in Table 3.1, it can be seen that MC, as a special market program, relies both on the push (i.e., the prior preparation of standard products) and pull (i.e., the post creation of customized products) strategies, the involved brands control their inventories by offering a limited range of customization choices to the consumers. Some MC brands, like Nike, and Shoes of Prey, also prefer to offer an unconditionally consumer returns policy for their consumers to return unsatisfactory products.

[19] It is clearly claimed by Shoes of Prey on its official link https://www.shoesofprey.com/help.

Besides, it is also common in MC practice to outsource the production and manufacturing activities to external third parties.

Table 3.1 A summary of the MC schemes in Nike, and Shoe of Prey

Category	Online platform	Offline platform	Unconditional return	Full refund	Return service fee	Leadtime	Outsourcing production activities
Nike	Yes	Yes	Yes (within 30 days)	Yes	No for Nike members	3-5 weeks	Yes
Shoe of Prey	Yes	No	Yes (within 365 days)	Yes	Yes	2 weeks	Yes

In the meantime, however, although these strategies and policies can enhance the performance of MC, the final benefits of these competing MC providers can still be substantially reduced if the inventory planning process is not well managed, e.g., a low inventory service level prepared for the basic products, the poor information management of the customer needs, and the over-customization on the basic items. Furthermore, the supply chains of MC brands sometimes may not be responsive and flexible enough to handle the customization requirements received from their consumers. Even for a giant brand like Nike, it takes 3-5 weeks to finish the MC process (see Table 3.1). Therefore, analysis on the ways to improve the response of the MC supply chain, such as the quick response strategy is necessary. Besides, the returned MC products can also lead to additional problems for the MC brands as well as related manufacturers. For instance, there is little chance to find someone else who has the interest in the same product and thus the MC brands probably have to bear the loss of these returns if they fail to find another alternative way to utilize these returned items. Apart from this, since the sustainability issue has also been increasingly emphasized by the consumers in the fashion market in recent years, devoting more time and effort into managing leftover inventories, including both the unsold leftovers and consumer returned items, is definitely beneficial to those MC companies.

Consequently, given the popularity of MC and related practice presented above, later sections of this thesis conduct deep analytical analysis on a fashion MC supply chain with consumer returns, from both the perspectives of the information updating and different salvage values of different leftovers.

The analytical model is established on the basis of these observations highlighted above and details are explained as follows: Firstly, we design a two-echelon fashion MC supply chain based on the practice of MC in fashion brands like Nike and Shoes of Prey, both of which have outsourced the production and manufacturing activities to external third parties (i.e., the manufacturers) and have strong market power to perform as the leader in the cooperative relationship. Secondly, the un-conditional full return policy is proposed for the established MC supply chain models. Thirdly, as can be seen from these cases, information updating is of great importance in guaranteeing the success of MC schemes, we therefore also investigate the quick response strategy (i.e., information updating) in the later analytical models.

4. Fashion Mass Customization Supply Chains with Consumer Returns

As is indicated in Chapter 2, the retailer-led scenario is still under explored in the existing literature in the domain of supply contracting with consumer returns (Guo et al., 2017). Besides, although there are many papers investigating the MC programs (e.g., Forza and Salvador (2008), Kuo (2013), and Li et al. (2016)) and consumer returns policies (e.g., Sheu et al. (2005), Xiao and Shi (2016), and Genc and De Giovanni (2017)), none of them has simultaneously discussed these two aspects together with the consideration of the salvage value of the unsold products and consumer returned items.

Therefore, given this research gap, and the growing power of fashion retailers as well as the existence of many retail programs such as MC nowadays (Chen and Xiao, 2009; Choi, 2013; Huang et al., 2002; Liu et al., 2012; Wang and Liu, 2007; Xiao et al., 2014; Yue et al., 2006), a fashion retail supply chain under a MC program, which involves an upstream manufacturer and a fashion retailer dealing with a single fashion product over a single selling period, is established in this chapter.[20] Under the MC program, the customers are allowed to make some reasonable[21] and minor customization changes on the basic products (e.g., a handbag) offered by the fashion retailer, and the retailer will then further customize these basic items according to the customization requirements passed by the customers (e.g., the addition of some special accessories or some personal printed messages). Such MC programs can be widely observed from the real world like the soccer jersey MC programs in the fashion industry and the MC schemes in electronic products (e.g. iPads in Apple). Besides, in this chapter, we consider the case when both of these two supply chain players are risk-neutral and profit seeking.

[20] As a remark, most part of this chapter is published in Choi and Guo (2018).

[21] “Reasonable” in this thesis means the customization changes required by the consumers should be practical according to the characteristics the products offered by the fashion retailer.

4.1 Model Formulation

In this supply chain, we assume that the fashion retailer needs to purchase the basic[22] product (i.e., un-customized product) from the upstream manufacturer before the start of the mass customization program, which are temporarily held by the manufacturer. After receiving requests from the consumers, the manufacturer will customize these basic products according to the requirements passed by the fashion retailer on each item and delivery the finished products to the fashion retailer before the start of the selling season. These requirements, for example, can be the customization requests on a specific color scheme or material of the basic items, which is common in various MC programs like NIKEiD and miAdidas. At the same time, unconditional returns and a full refund is guaranteed by the fashion retailer if the customized product fails to satisfy the consumer[23]. This kind of return policy gives the consumers some control of the product they have purchased and is a commonly observed case when implementing a mass customization program in the fashion industry.

In this two-echelon fashion supply chain, the fashion retailer is the leader and is responsible for deciding the ordering quantity before the start of the selling season. We also assume that the order can be placed either at Time 0 (the case without quick response) or Time 1 (with quick response), and the upstream manufacturer, acting as the supplier, is also believed to have enough capability to fulfill either order (i.e., perfectly reliable). The sequence of events is summarized as follows.

(1) Before the start of the mass customization program, the fashion retailer determines the ordering quantity for the un-customized items and submits the order to the manufacturer either at Time 0 or Time 1.

(2) The manufacturing activities are processed according to the order placed by the fashion retailer and the un-customized items will be temporarily held by the

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[22] Notice that in this thesis, we use the terms "the basic product" and "the un-customized product" interchangeably.

[23] This assumption is made based on the observation of MC practice in Chapter 3, i.e., both Nike and Shoe of Prey have provided this kind of consumer return policy.

manufacturer.

(3) Specific mass customization requests are made by the consumers and will be passed by the fashion retailer to the manufacturer.

(4) The manufacturer further customizes each basic item based on these requests and deliveries the finished ones to the retailer before the start of the selling season.

(5) Demand for the mass customized products is realized.

(6) The consumers return those unsatisfied products (i.e. failed products) back to the fashion retailer and receive full refund from the fashion retailer.

(7) The fashion retailer salvages both the leftover products and consumer returned items at the end of the selling season, both of which have a same salvage value.

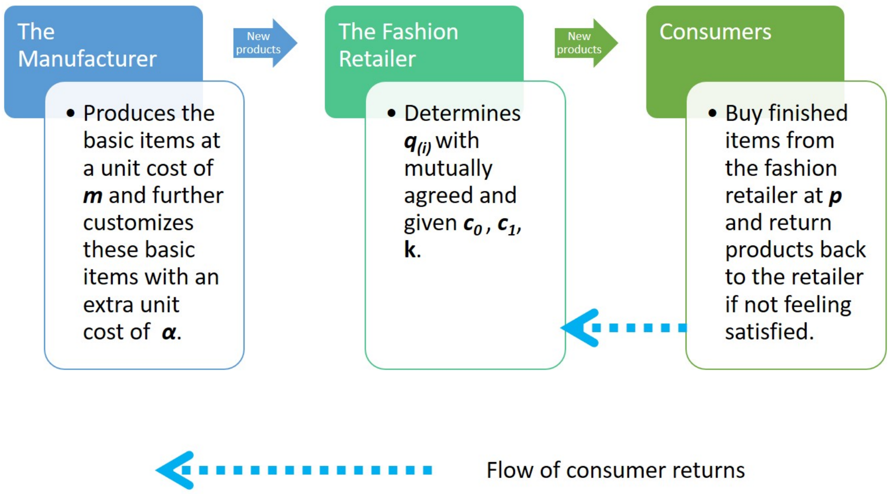

Figure 4.1 A mass customization fashion supply chain with consumer returns

The corresponding MC model is exhibited in Figure 4.1 and the revenue-cost parameters[24] are explained as follows: The fashion retailer firstly places an ordering quantity q of the un-customized products based on the demand forecast. The unit ordering cost of the basic items at Time 0 and Time 1 are c_0 and c_1,

[24] As a remark, the mathematical notation and symbols are consistently used in this chapter only, i.e., they may have different meanings in Chapter 5.

respectively. The mass customized items are sold at a unit retail price p in the consumer market. The fashion retailer will pay the manufacturer an extra unit ordering cost with a value of k for these customized items[25]. The manufacturer has to tackle a unit production cost m for the un-customized products and an extra unit expense of α for executing customization on the basic items. Reselling is not permitted in this model and as a result, by the end of the selling season, the fashion retailer salvages both the leftover products and consumer returns at a unit value of v. Besides, the consumer return rate is denoted by λ, which can be observed from the history data collected by the fashion retailer. Furthermore, in our model, the information sharing between these two payers is assumed to be symmetric and the manufacturer has full access to the related information from the retailer, such as the return rate.

To avoid trivial cases, the revenue-cost parameters are assumed to satisfy $p > c_i + k > v, c_i > m > v,\ k > \alpha$, and $0 < \lambda < 1$, where *i=0* or *1*. The unit ordering cost for these un-customized products at Time 1 is also supposed to be larger than the one at Time 0, i.e., $c_1 > c_0$, considering induced extra expenses like the increased human resources cost and logistics cost due to the time limitation.

In addition, for ease of presentation, we let subscript *r, m, sc, i, QR* denote the retailer, the manufacturer, the entire supply chain, the related time stage, and the quick response strategy, respectively. Let superscript * denote the optimal solution of the corresponding decision variables and let superscripts *C, R, T,* and *H* represent the centralized model, the decentralized model under the leadership of the retailer, the decentralized model under the coordination of a two-part tariff contract, and the decentralized model coordinated by a hybrid contract which combines a buyback contract with a two-part tariff` contract.

For the market demand, we follow the Bayesian information updating[26]

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[25] It is a reasonable assumption since nowadays, many MC companies use the third parties to finish some or even the entire processes of MC production and one famous instance is Nike, which outsources the entire production.

[26] It is a theory frequently utilized to capture the demand uncertainty structure in an environment with information updating. Under this theory, the variance of the market demand consists of both the inherent demand uncertainty of the product (i.e., δ) as well as the deductible forecast variance (i.e., d_0 and d_1). The inherent demand uncertainty of the product is something that cannot be further reduced by QR, which means that even if the market information about the mean demand is perfect, the market demand is still a random variable. Besides, with the updated information, the forecast variance under QR is smaller than the one under the slow response strategy, i.e., $d_0 > d_1$ (Iyer and Bergen, 1997).

model for demand uncertainty and since it is already a well-known model in the literature, we just briefly show the model below. Interested readers can refer to Iyer and Bergen (1997), Choi et al., (2003) and Choi and Chow (2008) for more details. Under this demand structure, if the fashion retailer orders the basic items at Time 0, the forecasted demand in the consumer market is x_0, and it follows a normal distribution $x_0 \sim N\ (\mu_0, d_0 + \delta)$. However, if the retailer places an order under the quick response strategy, i.e., Time 1, then according to the Bayesian normal conjugate pair theory, the updated market demand follows $x_1 \sim N\ (\mu_1, d_1 + \delta)$, $d_1 = \frac{d_0\delta}{d_0+\delta}$ and $\mu_1 \sim N\ (\mu_0, \frac{d_0^2}{d_0+\delta})$. We define $f(\cdot)$ and $F(\cdot)$ as the standard normal density function and the standard normal cumulative distribution function, respectively, and let $F^{-1}(\cdot)$ be the inverse function of $F(\cdot)$. Furthermore, we also represent the standard normal right linear loss function as *Z(x)*, which can be expressed by: $Z(x) = \int_x^\infty (y - x)f(y)dy$.

The notations used in this chapter are listed in Table 4.2 for readers' reference.

Table 4.2 Notions in the analytical model in Chapter 4 (*i=0,1*)

Parameters	Description
p	Unit retail price of the mass customized product paid by the consumer to the fashion retailer
$q_{(i)}$	The order quantity of the basic items decided by the fashion retailer (at Time *i*)
$c_{(i)}$	Unit ordering cost of the un-customized product paid by the fashion retailer to the manufacturer (at Time *i*)
k	Extra unit ordering cost for mass customization program paid by the fashion retailer to the manufacturer
m	Unit production cost of the un-customized products
v	Unit salvage value of the leftover products and customer returns
α	Extra unit production cost for executing customization on the basic products
s	The service level under the chosen ordering quantity
λ	Consumer return rate based on the observation of history data
x	Market demand for the fashion product
$f(x)$	The standard normal density function of the market demand *x*
$F(x)$	The standard normal cumulative distribution function of the market demand *x*
$\pi_{r,i}$	The profit function of the fashion retailer at Time *i*
$\pi_{m,i}$	The profit function of the upstream manufacturer at Time *i*
$\pi_{SC,i}$	The profit function of the whole MC supply chain at Time *i*
$E[\pi_{r,i}]$	The expected profit of the fashion retailer at Time *i*
$E[\pi_{m,i}]$	The expected profit of the upstream manufacturer at Time *i*

$E[\pi_{SC,i}]$	The expected profit of the whole MC supply chain at Time *i*
$EPQR_r$	The net profit gained by the fashion retailer by adopting the QR strategy
$EPQR_m$	The net profit gained by the upstream manufacturer by adopting the QR strategy
$EPQR_{SC}$	The net profit gained by the fashion supply chain by adopting the QR strategy
$E[\pi_r^T(q)]$	The expected profit of the fashion retailer at Time *1* under a two-part tariff contract
$E[\pi_m^T(q)]$	The expected profit of the manufacturer at Time *1* under a two-part tariff contract
$EPQR_r^T$	The net profit gained by the fashion retailer when participating in a two-part tariff contract under the QR strategy
$EPQR_m^T$	The net profit gained by the manufacturer when participating in a two-part tariff contract under the QR strategy
$E[\pi_r^H(q)]$	The expected profit of the fashion retailer at Time *1* under a hybrid contract
$E[\pi_m^H(q)]$	The expected profit of the manufacturer at Time *1* under a hybrid contract
$EPQR_r^H$	The net profit gained by the fashion retailer when coordinated by a hybrid contract under the QR strategy
$EPQR_m^H$	The net profit gained by the manufacturer when coordinated by a hybrid contract under the QR strategy
$EPQR_{SC}^H$	The net profit gained by the whole supply chain when coordinated by a hybrid contract under the QR strategy

In the following sections, the decision making problem in a centralized supply chain setting will be analyzed first, followed by the discussion on a decentralized setting, which is under the leadership of the fashion retailer. Finally, the application and performance of several supply chain contracts in this fashion supply chain are investigated before deriving conclusive remarks for this chapter. We propose several supply chain contracts that can help achieve a win-win outcome or supply chain coordination.

4.2 Decisions in the Centralized Setting

The centralized decision system in this section provides a benchmark to make a comparison with the decentralized decision system (i.e., when is led by the fashion retailer) in terms of the channel performance. Under the centralized model, it is assumed that the manufacturer and the retailer are vertically integrated and they perform as a central decision maker who determines all relevant decisions aiming at maximizing the total profit of the entire chain. The profit functions of the whole channel can be derived by respectively examining the expected profit of the fashion retailer and the expected profit the manufacturer first. Therefore, we now proceed to determine the retailer's profit at Time 0.

Based on the mass customization model presented above, we have the profit function of the fashion retailer at Time 0 as:

$$\pi^C_{r,0}(q) = pmin(x,q) - c_0q - kmin(x,q) + vmax(q-x,0) - \lambda pmin(x,q) + v(\lambda min(x,q)). \quad (4.1)$$

Note that, in (4.1), $pmin(x,q)$ is the revenue generated from selling the mass customized products to the customers, c_0q is the ordering cost of the un-customized products, $kmin(x,q)$ is the extra ordering cost of the customized products, $vmax(q-x,0)$ is the revenue attained from salvaging the leftover items. As a consequence, the first four elements give the profit of the fashion retailer at Time 0 when no consumer returns are permitted in the channel. In the meanwhile, the last two elements are the cost and the salvage value that the fashion retailer receives from the unconditional consumer return for the mass customization program. Based on the above discussion, $\pi^C_{r,0}(q)$ can be written as

$$\pi^C_{r,0}(q) = (p-k-\lambda p+v\lambda)min(x,q) - c_0q + vmax(q-x,0).$$

Define $\tau = (1-\lambda)p + v\lambda - k = p - k - (p-v)\lambda$, then we have:

$$\pi^C_{r,0}(q) = (\tau - c_0)q - (\tau - v)max(q-x,0).$$

By taking expectation, it can be found that the expected profit of the fashion retailer at Time 0 is:

$$E[\pi^C_{r,0}(q)] = (\tau - c_0)q - (\tau - v)\int_{-\infty}^{q}(q-x)f(x)dx.$$

Similarly, at Time 1, the expected profit of the fashion retailer is:

$$E[\pi^C_{r,1}(q)] = (\tau - c_1)q - (\tau - v)\int_{-\infty}^{q}(q-x)f(x)dx.$$

After exploring the expected profit of the fashion retailer, we then explore the profit function of the upstream manufacturer at Time 0, which can be derived as:

$$\pi^C_{m,0}(q) = c_0q + kmin(x,q) - mq - \alpha min(x,q). \quad (4.2)$$

Notice that the first two components in (4.2) are the revenue received from the fashion retailer while the remaining twos are the production costs that the manufacturer has to bear. It can be found that the expected profit of the manufacturer at Time 0 is:

$$E[\pi_{m,0}^{C}(q)] = (c_0 + k - m - \alpha)q - (k - \alpha)\int_{-\infty}^{q}(q-x)f(x)dx. \quad (4.3)$$

Similarly, at Time 1, the expected profit of the manufacturer is:

$$E[\pi_{m,1}^{C}(q)] = (c_1 + k - m - \alpha)q - (k - \alpha)\int_{-\infty}^{q}(q-x)f(x)dx.$$

According to $\pi_{SC}(q) = \pi_r(q) + \pi_m(q)$, it is straightforward that:

$$E[\pi_{sc,0}^{C}(q)] = (\tau + k - \alpha - v)\mu_0 - (m - v)q - (\tau + k - \alpha - v)\int_{q}^{\infty}(x-q)f(x)dx. \quad (4.4)$$

Observe that, under the condition of $\lambda < 1 - \frac{k}{p-c_1}$, $E[\pi_{sc,0}^{C}(q)]$ is concave function of q (refer to Appendix (B1) for the details). As a remark, the above condition guarantees the extra unit ordering cost for the mass customized items (k) is much smaller than the retailer's profit margin, which holds in most cases. Therefore, the optimal ordering quantity at Time 0, which maximizes the expected profit of the whole supply chain, can be derived as follows, by using the first-order condition:

$$q_0^{C*} = \mu_0 + \sqrt{d_0 + \delta}F^{-1}\left(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v}\right). \quad (4.5)$$

Substitute (4.5) into (4.4) gives the optimal expected profit function of the whole supply chain at Time 0:

$$E[\pi_{sc,0}^{C*}(q_0^{C*})] = (\tau + k - \alpha - v)\mu_0 - (m - v)q_0^{C*} - (\tau + k - \alpha - v)\sqrt{d_0 + \delta}Z(F^{-1}(s_0^{C*})),$$

where $s_0^{C*} = \frac{\tau+k-\alpha-m}{\tau+k-\alpha-v} = \frac{p-(p-v)\lambda-\alpha-m}{p-(p-v)\lambda-\alpha-v}$ is the optimal service level at Time 0 in the centralized setting.

Similarly, at Time 1, it can be verified that the expected profit of the entire chain, the corresponding optimal ordering quantity and optimal expected profit are follows:

$$E[\pi_{sc,1}^{C}(q)] = (\tau + k - \alpha - v)\mu_1 - (m - v)q - (\tau + k - \alpha - v)\int_{q}^{\infty}(x-q)f(x)dx,$$

$q_I^{C*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v})$,

$E[\pi_{sc,1}^{C*}(q_1^{C*})] = (\tau + k - \alpha - v)\mu_1 - (m - v)q_1^{C*} - (\tau +$

$k - \alpha - v)\sqrt{d_1 + \delta}Z(F^{-1}(s_I^{C*}))$,

where $s_I^{C*} = \frac{\tau+k-\alpha-m}{\tau+k-\alpha-v} = \frac{p-(p-v)\lambda-\alpha-m}{p-(p-v)\lambda-\alpha-v} = s_0^{C*}$.

4.3 Decisions in the Decentralized Setting

In the decentralized system, considering the leadership of the fashion retailer (e.g., Nike, which is with dominant market power), the fashion retailer first determines the ordering quantity of the un-customized products at either Time 0 or Time 1, aiming at maximizing his own profit rather than the whole supply chain's profit. Afterwards, the upstream manufacturer reacts and fulfills the order, taking the fashion retailer's decisions into consideration.

In the following, the situation when the order is placed at Time 0 will be discussed first:

(A) The profit function of the fashion retailer:

Based on the formulation and arguments in previous sections, it is straightforward that the expected profit function of the fashion retailer in the decentralized supply chain setting is:

$$E\left[\pi_{r,0}^{R}(q)\right] = (\tau - v)\mu_0 - (c_0 - v)\, q - (\tau - v)\sqrt{d_0 + \delta}Z(\frac{q - \mu_0}{\sqrt{d_0 + \delta}}) \quad (4.6)$$

Similar to Section 4.2, when $\lambda < 1 - \frac{k}{p-c_1}$, we can observe that $E[\pi_{r,0}^{R}(q)]$ is concave function (details can be found in Appendix (B2)).

Thus, at Time 0, the optimal ordering quantity, which maximizes the expected profit of the fashion retailer, is given as:

$$q_0^{R*} = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(\frac{\tau - c_0}{\tau - v}). \quad (4.7)$$

By substituting (4.7) into (4.6), we have the optimal expected profit function of the fashion retailer at Time 0 below:

$E\left[\pi_{r,0}^{R*}(q_0^{R*})\right] = (\tau - v)\mu_0 - (c_0 - v)q_0^{R*} - (\tau - v)\sqrt{d_0 + \delta}Z\left(F^{-1}(s_0^{R*})\right)$, where $s_0^{R*} = \frac{\tau - c_0}{\tau - v} = \frac{p-(p-v)\lambda-k-c_0}{p-(p-v)\lambda-k-v}$ is the optimal service level at Time 0 under the decentralized situation, which is under the leadership of the fashion retailer.

Similarly, if the order is placed at Time 1, it can be found that the expected profit of the fashion retailer, the optimal ordering quantity chosen by the fashion retailer and his corresponding optimal expected profit are listed as follows:

$E[\pi_{r,1}^{R}(q)] = (\tau - v)\mu_1 - (c_1 - v)\, q - (\tau - v)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}})$,

$q_1^{R*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau - c_1}{\tau - v})$,

$E[\pi_{r,1}^{R*}(q_1^{R*})] = (\tau - v)\mu_1 - (c_1 - v)q_1^{R*} - (\tau - v)\sqrt{d_1 + \delta}Z(F^{-1}(s_1^{R*}))$,

where $s_1^{R*} = \frac{\tau - c_1}{\tau - v} = \frac{p-(p-v)\lambda-k-c_1}{p-(p-v)\lambda-k-v}$.

As a remark, it is assumed that $c_1 > c_0$, which is the result of various extra costs induced by the time limitation for production as well as delivery activities, it is obvious that $s_0^{R*} > s_1^{R*}$.

(B) The profit function of the manufacturer:

By substituting $q_0 = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(y)$ into the expected profit of the upstream manufacturer, which is listed in Section 4.2 as (4.3), we have:

$E[\pi_{m,0}^{R}(q)] = (k - \alpha)\mu_0 - (m - c_0)q - (k - \alpha)\sqrt{d_0 + \delta}Z(\frac{q - \mu_0}{\sqrt{d_0 + \delta}})$.

In addition, considering the leadership of the retailer, when the fashion retailer's ordering quantity equals q_0^{R*} at Time 0, we have the updated expected profit function of the manufacturer as:

$E[\pi_{m,0}^{R}(q_0^{R*})] = (k - \alpha)\mu_0 - (m - c_0)\, q_0^{R*} - (k - \alpha)\sqrt{d_0 + \delta}Z(F^{-1}(\frac{\tau - c_0}{\tau - v}))$.

Following the same logic as shown above, at Time 1, $E[\pi_{m,1}^{R}(q)]$ and $E\left[\pi_{m,1}^{R}\left(q_1^{R*}\right)\right]$ can be derived as follows:

$E[\pi_{m,1}^{R}(q)] = (k - \alpha)\mu_1 - (m - c_1)q - (k - \alpha)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}})$.

$E[\pi_{m,1}^{R}(q_1^{R*})] = (k - \alpha)\mu_1 - (m - c_1)\, q_1^{R*} - (k - \alpha)\sqrt{d_1 + \delta}Z(F^{-1}((\frac{\tau - c_1}{\tau - v}))$.

4.4 Discussions

4.4.1 Comparisons between the Centralized and Decentralized Systems

Observe from the previous two sections, we have Table 4.3, which concludes two different optimal ordering quantities under both kinds of supply chain structures.

Table 4.3 Optimal ordering quantity under different structures at different time stages

Two basic scenarios	In the centralized setting	In the decentralized setting
Time 0	$q_0^{C*} = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v})$;	$q_0^{R*} = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(\frac{\tau-c_0}{\tau-v})$;
Time 1	$q_1^{C*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}\left(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v}\right)$.	$q_1^{R*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau-c_1}{\tau-v})$.

By comparing these two different optimal ordering quantities, some findings are summarized as follows:

First, no matter at which time stage, the optimal ordering quantity from the aspect of the fashion retailer is always different from the one from the supply chain's perspective. This phenomenon reveals the existence of double marginalization in the decentralized setting, which decreases the performance of MC program. It is natural since the fashion retailer (e.g., Nike, which has outsourced its production and manufacturing activities instead of vertically integrating the whole fashion supply chain like Zara), does not have the incentive to consider the performance of the whole supply chain if without any additional benefits. It can also be observed from the models proposed in other studies like Iyer and Bergen (1997) and Choi (2016). Additionally, the empirical analyses in Ro et al. (2007) and Zhang et al. (2014b) have shown the existence of this phenomenon when executing MC in the real world, as well.

Second, the optimal service level under the centralized situation is exactly the same at Time 0 and Time 1. However, it is different in the decentralized mode. In the decentralized setting, the service level at Time 1 is smaller than the one at Time 0 owing to the increased wholesale price of the basic item (i.e., $c_1 > c_0$). *That is, under the MC program, the optimal service level in the centralized scenario is* *independent of* c_i *while it is negatively related to the unit ordering cost of the un-customized product* c_i *in the decentralized scenario.*

4.4.2 Comparisons of the Decentralized Models under Different Time Stages

From the view of a channel, the comparisons of the expected profits of both the fashion retailer and the manufacturer (in the decentralized model) between two different time stages, i.e., Time 0 and Time 1, can help examine whether the quick response strategy is beneficial to each individual player under the MC program. Therefore, their respective expected profits under the corresponding optimal ordering quantity are listed in Table 4.4. In the meantime, analyses on the net profits gained by these two players after adopting QR strategy under different conditions of c_1 are shown in Table 4.5, which leads to Lemma 4.1.

Table4.4 Expected profits of the two members under different time stages

In the decentralized setting	The retailer	The manufacturer
Time 0	$E[\pi_{r,0}^{R*}(q_0^{R*})] =$ $(\tau - v)\mu_0 - (c_0 - v)\, q_0^{R*} - (\tau - v)\sqrt{d_0 + \delta} ZF^{-1}(q_0^{R*}));$	$E[\pi_{m,0}^{R}(q_0^{R*})] =$ $(k - \alpha)\mu_0 - (m - c_0)\, q_0^{R*} - (k - \alpha)\sqrt{d_0 + \delta} Z(F^{-1}(\frac{\tau - c_0}{\tau - v}));$
Time 1	$E[\pi_{r,1}^{R*}(q_1^{R*})] =$ $(\tau - v)\mu_1 - (c_1 - v)\, q_1^{R*} - (\tau - v)\sqrt{d_1 + \delta} ZF^{-1}(q_1^{R*})).$	$E[\pi_{m,1}^{R}(q_1^{R*})] =$ $(k - \alpha)\mu_1 - (m - c_1)\, q_1^{R*} - (k - \alpha)\sqrt{d_1 + \delta} Z(F^{-1}((\frac{\tau - c_1}{\tau - v})).$

Table 4.5 The net profit gained by the two players under the QR strategy

The value of c_1	The retailer	The manufacturer	The supply chain
Situation I: $(\tau - v)\sqrt{d_1 + \delta}f(F^{-1}(s_I^{R*})) + c_1\mu_0 > (\tau - v)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$, and $[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (k-\alpha)\sqrt{d_1+\delta}f(F^{-1}(s_I^{R*}) + c_1\mu_0 < [(k-\alpha)(1- s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (k-\alpha)\sqrt{d_0+\delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$	$EPQR_r^R < 0$	$EPQR_m^R < 0$	$EPQR_{SC}^R < 0$
Situation II: $(\tau - v)\sqrt{d_1 + \delta}f(F^{-1}(s_I^{R*})) + c_1\mu_0 > (\tau - v)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$, and $[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (k-\alpha)\sqrt{d_1+\delta}f(F^{-1}(s_I^{R*}) + c_1\mu_0 > [(k-\alpha)(1- s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (k-\alpha)\sqrt{d_0+\delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$	$EPQR_r^R < 0$	$EPQR_m^R > 0$	$EPQR_{SC}^R > 0$ if $s_I^{R*} < s_0^{R*} < 0.5$; otherwise, it depends.
Situation III: $(\tau - v)\sqrt{d_1 + \delta}f\left(F^{-1}(s_I^{R*})\right) + c_1\mu_0 < (\tau - v)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$, and $[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (k-\alpha)\sqrt{d_1+\delta}f(F^{-1}(s_I^{R*}) + c_1\mu_0 < [(k-\alpha)(1- s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (k-\alpha)\sqrt{d_0+\delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$	$EPQR_r^R > 0$	$EPQR_m^R < 0$	It depends.
Situation IV: $(\tau - v)\sqrt{d_1 + \delta}f\left(F^{-1}(s_I^{R*})\right) + c_1\mu_0 < (\tau - v)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$, and $[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (k-\alpha)\sqrt{d_1+\delta}f(F^{-1}(s_I^{R*}) + c_1\mu_0 > [(k-\alpha)(1- s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (k-\alpha)\sqrt{d_0+\delta}f(F^{-1}(s_0^{R*})) + c_0\mu_0$	$EPQR_r^R > 0$	$EPQR_m^R > 0$	$EPQR_{SC}^R > 0$

Note that, for Situation II:

When $s_I^{R*} < s_0^{R*} < 0.5$, $\sqrt{d_1 + \delta}f\left(F^{-1}(s_I^{R*})\right) < \sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*}))$, therefore $EPQR_{SC}^R > 0$.

When $s_0^{R*} > s_I^{R*} > 0.5$, $EPQR_{SC}^R > 0$ if and only if c_1 satisfies:

$$[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (p-\alpha-v-(p-v)\lambda)\sqrt{d_1+\delta}f\left(F^{-1}(s_I^{R*}\right) > [(k-\alpha)(1- s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (p-\alpha-v-(p-v)\lambda)\sqrt{d_0+\delta}f\left(F^{-1}(s_0^{R*})\right).$$

For Situation III:

For both $s_0^{R*} > s_I^{R*} > 0.5$ and $s_I^{R*} < s_0^{R*} < 0.5$, $EPQR_{SC}^R > 0$ if and only if c_1

satisfies:

$$[(k-\alpha)(1-s_1^{R*}) + (c_1-m)]\sqrt{d_1+\delta}F^{-1}(s_1^{R*}) - (p-\alpha-v-(p-v)\lambda)\sqrt{d_1+\delta}f\left(F^{-1}(s_I^{R*})\right) > [(k-\alpha)(1-s_0^{R*}) + (c_0-m)]\sqrt{d_0+\delta}F^{-1}(s_0^{R*}) - (p-\alpha-v-(p-v)\lambda)\sqrt{d_0+\delta}f\left(F^{-1}(s_0^{R*})\right).$$

Lemma 4.1. Under the MC program, none of these two players definitely acquires a higher profit at Time 1 than Time 0 in the decentralized model and the whole fashion supply chain may also suffer.

Proof: See Appendix (B3).

Lemma 4.1 shows that the quick response policy in the decentralized fashion supply chain with the MC program has the chance to bring some loss to either the fashion retailer or the upstream manufacturer, or even both of them. In fact, according to Table 4.5, only under Situation IV, can both of these two players gain more profits after adopting the quick response strategy.

4.4.3 Conclusion

The comparisons in both of these two subgroups show that some coordination strategies should be developed in order to motivate the members' collaboration when they establish a cooperative relationship, and hence to improve the entire performance of the decentralized structure. Therefore, in the following, we will discuss how the channel performance can be enhanced with the help of some supply chain contracts. Note that, in later discussion, we only consider the situation when $s_0^{R*} > s_I^{R*} > 0.5$, since we usually will not expect to observe a service level lower than 0.5 in practice (Iyer and Bergen, 1997).

4.5 All-Win Situation and Supply Chain Coordination

After the exploration on both the centralized and decentralized setting, the methods to improve the performance of the decentralized supply chain under the MC program will be analyzed next. This section starts with a discussion on the ways to achieve a win-win outcome for these two members. As a remark, in this chapter, we still assume that the fashion supply chain is under the leadership of the fashion retailer since many MC brands, like Nike, have enough power to lead the cooperative relationship with the outsourced manufacturer. That is, the retailer first decides the ordering quantity and then the upstream manufacturer is responsible for offering reliable production service.

4.5.1 All-Win Situation after Using Quick Response

A win-win outcome implies that both the fashion retailer and the upstream manufacturer are able to gain more profits than the initial situation. It is undoubted that if a proposed contract can lead to a greater profit to both of these two members when compared to the non-cooperative scenario, then the contract can always be successfully implemented.

In the following, we study the situation when the fashion retailer designs a two-part tariff contract, which includes two parameters $(m,\ A)$ and is supposed to be available at Time 1 only, and offers it to the upstream manufacturer aiming at achieving a win-win situation for the channel. The first parameter means that the manufacturer will agree to charge the fashion retailer a unit ordering cost of the basic items that is just sufficient enough to recover his unit production cost of these items. In the meantime, the fashion retailer has to pay a lump-sum fee A to the manufacturer in order to compensate the loss of the manufacturer for lowering the wholesale price. Thus, the unit ordering cost for the un-customized products becomes $m+\frac{A}{q}$, where q is the ordering quantity, and the updated expected profits of these two players are:

$$E\left[\pi_{r,1}^{T}(q)\right]=(\tau-v)\mu_1-\left(m+\frac{A}{q}-v\right)q-(\tau-v)\sqrt{d_1+\delta}Z\left(\frac{q-\mu_I}{\sqrt{d_I+\delta}}\right)-A,$$

$$E\left[\pi_{m,1}^{T}(q)\right]=(k-\alpha)\mu_1-\left(m-\left(m+\frac{A}{q}\right)\right)q-(k-\alpha)\sqrt{d_1+\delta}Z\left(\frac{q-\mu_I}{\sqrt{d_I+\delta}}\right)+$$

$$A.$$

We can also derive the optimal ordering quantity of the retailer under this contract (when $\lambda < 1 - \frac{k}{p-c_1}$) as follow: $q^{T*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau - m}{\tau - v})$ and the corresponding optimal service level $s^{T*} = \frac{\tau - m}{\tau - v}$.

In addition, we define the net profits gained by the retailer and the manufacturer after participating in a two-part tariff contract at Time 1 as $EPQR_r^T$, and $EPQR_m^T$, respectively.

Note that, $EPQR_r^T = E[\pi_{r,1}^T(q^{T*})] - E[\pi_{r,0}^{R*}(q_0^{R*})]$, (4.8)

and $EPQR_m^T = E[\pi_{m,1}^T(q^{T*})] - E[\pi_{m,0}^{R*}(q_0^{R*})]$. (4.9)

Lemma 4.2. (a) The fashion MC supply chain can achieve a win-win result after adopting quick response via a two-part tariff contract, by setting the value of A with which (i) $EPQR_r^T > 0$ and (ii) $EPQR_m^T > 0$; (b) The sufficient condition for achieving a win-win outcome is that the value of A should satisfy: $\underline{A} < A < \overline{A}$, where:

$\underline{A} = (c_0 - m)\mu_0 - [\frac{(k-\alpha)(m-v)}{p-(p-v)\lambda-k-v}]\sqrt{d_1 + \delta}F^{-1}(s^{T*}) + [\frac{(k-\alpha)(c_0-v)}{p-(p-v)\lambda-k-v} - (m - c_0)]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) - (k-\alpha)(\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta}f(F^{-1}(s^{T*})))$

, and $\overline{A} = (p - k - (p - v)\lambda - v)[\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta}f(F^{-1}(s^{T*}))] - (m - c_0)\mu_0$.

Proof of Lemma 4.2.(a) can be derived from the definition. For Lemma 4.2.(b), please refer to Appendix (B4).

Lemma 4.2 gives the condition when the proposed two-part tariff contract can be successfully implemented. As shown above, these two channel members will agree this contract if both of them can receive higher profits than without the contract. As a remark, the upper bound on the fixed payment A given in Lemma 4.2(b) determines the constraint beyond which the fashion retailer would not participate and the lower bound decides the constraint below which the manufacturer would not join.

4.5.2 Supply Chain Coordination

According to the analysis above, we find that the decentralized supply chain system has a lower profitability than the centralized one, which is the consequence of the double marginalized effect. That is, the performance of the whole supply chain can be further improved by coordinating the involved members. Note that, in this thesis, a coordinated supply chain refers to the situation when the expected profit of the supply chain is maximized, which can be easily attained in a centralized and complete information sharing supply chain structure. If under a decentralized setting, however, some carefully designed supply chain contracts are needed to ensure the participation of all players in a centralized setting. Therefore, under the quick response strategy, in order to coordinate the manufacturer–retailer link in the fashion MC supply chain, we assume that the fashion retailer proposes a hybrid contract to the manufacturer. The hybrid contract, known as the buyback and two-part tariff contract, combines the decisions in a buyback and returns contract, and a two-part tariff contract. We also focus on the win-win coordination issue in this chapter to ensure the smooth implementation of the hybrid contract and the quick response policy under the condition of consumer returns. The win-win coordination with implementing QR is defined as the case when the supply chain members are all benefited by the implementation of QR and the supply chain system is also optimized at the same time (Choi, 2016).

The hybrid contract contains three parameters: the unit ordering cost m paid by the retailer for the basic items, which is equal to the manufacturer's unit production cost, the buyback price b paid by the manufacturer for each leftover items and consumer returns returned by the fashion retailer at the end of the selling season, and a lump-sum fee A paid by the retailer to the manufacturer in order to compensate the manufacturer's loss. To eliminate arbitrage value of the products returned by the retailer, we assume that $v < b < m$. Besides, we assume that the manufacturer can also have a salvage value of v, which is exactly the same with the situation salvaged by the retailer[27].

Under the assumptions given above, the revised expected profits of the upstream manufacturer and the fashion retailer are:

$$E\left[\pi_{r,1}^{H}(q)\right] = (\tau^{H} - m)q - (\tau^{H} - b)\int_{-\infty}^{q}(q - x)f(x)dx - A, \quad (4.10)$$

where $\tau^{H} = p - k - (p - b)\lambda$.

$$E\left[\pi_{m,1}^{H}(q)\right] = (k - \alpha - (b - v)\lambda)q - [k - \alpha + (b - v)(1 - \lambda)]\int_{-\infty}^{q}(q - x)f(x)dx + A.$$

By differentiating (4.10) once and twice with respect to q, we find that $E\left[\pi_{r,1}^{H}(q)\right]$ is concave when $\lambda < 1 - \frac{k}{p - c_1}$ and hence we can derive the optimal ordering quantity under the hybrid contract as (details are included in Appendix (B5)):

$q^{H*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau^{H} - m}{\tau^{H} - v})$, $s^{H*} = \frac{\tau^{H} - m}{\tau^{H} - v}$. Then we have Lemma 4.3.

Lemma 4.3. The fashion supply chain can achieve a win-win coordination (considering QR case only) by a hybrid contract, with the parameter $m = c$, $b = \frac{m[k - v(1 - \lambda) - \alpha] + v[p(1 - \lambda) - k]}{(p - m)(1 - \lambda) - \alpha}$, and with the parameter A in the range of $\underline{A} < A < \overline{A}$, where:

$$\underline{A} = [\frac{(k - \alpha)(c_0 - v)}{p - (p - v)\lambda - k - v} - (m - c_0)]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) + (k - \alpha + (b - v)(1 - \lambda))\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})) - [\frac{(k - \alpha + (b - v)(1 - \lambda))(m - b)}{p - (p - b)\lambda - k - b} - (b - v)]\sqrt{d_1 + \delta}F^{-1}(s^{H*}) - (k - \alpha)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - (m - c_0 - (b - v)\lambda)\mu 0,$$

$$\overline{A} = -(m - c_0 - (b - v)\lambda)\mu_0 + (p - k - (p - v)\lambda - v)\sqrt{d_0 + \delta}f(F^{-1}(s^{H*})) - (p - k - (p - b)\lambda - b)\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})).$$

Proof of Lemma 4.3: See Appendix (B6).

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[27] It happens when there is a common salvage market or recycle channel.

Lemma 4.3 indicates that a policy that combines the use of a buyback and returns policy and a two-part tariff policy can effectively lead to the win-win coordination for the fashion retail supply chain under a mass customization program with unconditional consumer returns. That is, both of the fashion retailer and the upstream manufacturer can be motivated by this contract since both of them can earn higher profits compared to the non-cooperative scenario and simultaneously the whole channel is also optimized. This result is consistent with our finding in Section 2.3.6, which states that higher efficiency can be achieved by applying other coordination settings, such as the hybrid contracts, instead of the single-contract setting when considering the consumer returns in a channel.

4.6. Numerical Analysis

To better illustrate our theoretical results shown above, we then conduct a numerical analysis in the following (see Table 4.6). The corresponding parameters are set as below: p =22, c_1=5.5, c_0=5, m=2, k=4, α=1, v=0.5, λ=0.2, μ_0=12, d_0=14, δ=2, d_1=1.75. Results are presented in Table 4.6.

From the numerical results, we find that the optimal buyback price (b) specified in the hybrid contract is influenced by the manufacturer's unit production cost of the un-customized items (m), the extra unit ordering cost of the mass customized products (k) and the history consumer return ratio (λ). To be specific, increasing either of these three factors in this fashion supply chain can increase the optimal buyback price. Besides, among these three aspects, the impact brought by the history consumer return ratio is the most distinct and the optimal buyback price has a positive linear correlation with the extra unit ordering cost of the mass customized products.

As for the changes in the expected profits of the whole chain, which also equals to the length of the value range for A, we conclude them as follows. First, we find that the channel's expected profits under the hybrid contract increase with the extra unit ordering cost of the mass customized products (k) and the history consumer return ratio (λ). Second, the correlation between the expected profits of the whole fashion chain and the upstream manufacturer's unit production cost of the un-customized items is not obvious. Third, when the value of the extra unit ordering cost of mass customization program is large enough, the hybrid contract can contribute to a substantial increase in the whole supply chain's expected profit.

Table 4.6 Numerical analyses of the coordination under the hybrid contract

Case	m	c_0	$c_0 - m$	k	λ	b	Range of A	$EPQR_{SC}^{T}$
1	2	5	3	4	0.2	0.8	39.96< A<51.92	11.97
2	1	5	4	4	0.2	0.59	52.48< A<65.82	13.34
3	1.5	5	3.5	4	0.2	0.69	46.23< A<58.76	12.53
4	2.5	5	2.5	4	0.2	0.91	31.94< A<45.27	13.33
5	3	5	2	4	0.2	1.02	26.08< A<38.75	12.68
6	2	5	3	2	0.2	0.6	41.63< A<52.40	10.77
7	2	5	3	3	0.2	0.7	39.86< A<52.20	12.33
8	2	5	3	5	0.2	0.9	35.04< A<51.55	16.51
9	2	5	3	6	0.2	1	31.69< A<51.06	19.37
10	2	5	3	4	0.1	0.76	39.55< A<53.02	13.47
11	2	5	3	4	0.15	0.78	38.70< A<52.50	13.80
12	2	5	3	4	0.25	0.82	36.56< A<51.28	14.72
13	2	5	3	4	0.3	0.85	35.18< A<50.55	15.37

% change in $EPQR_{SC}^{T}$			
Case 2 VS Case 1	11.44%	Case 3 VS Case 1	4.68%
Case 4 VS Case 1	11.36%	Case 5 VS Case 1	5.93%
Case 6 VS Case 1	-10.02%	Case 7 VS Case 1	3.00%
Case 8 VS Case 1	37.93%	Case 9 VS Case 1	61.82%
Case 10 VS Case 1	12.53%	Case 11 VS Case 1	15.29%
Case 12 VS Case 1	22.97%	Case 13 VS Case 1	28.40%

4.7 Summary

The analytical model presented above considers the application of the quick response strategy in the fashion MC program, with consumer returns allowed. Some parameters which are commonly omitted in other studies, like the unit extra ordering cost for every MC product and the difference between the unit ordering cost of the basic products at two different time stages, have been investigated in this chapter.

Based on the established model above, we find that the optimal ordering quantity from the aspect of the fashion retailer is always different from the optimal one for the whole supply chain, and the whole fashion supply chain under the MC program can achieve a win-win result after adopting quick response if both players agree to cooperate via a two-part tariff. Furthermore, a win-win outcome can also be achieved by a hybrid contract, which is based on the combination of a buyback and returns contract, and a two-part tariff contract.

Besides, as is illustrated in numerical examples, the optimal buyback price specified in the hybrid contract is positively influenced by the manufacturer's unit production cost of the un-customized items, the extra unit ordering cost of the mass customized products as well as the history consumer return ratio. In addition, the positive linear correlation between the optimal buyback price and the extra unit ordering cost of the mass customized products has also been found in the numerical analyses.

As is shown in Chapter 3's case studies, MC brands like Nike commonly outsource their entire production process of MC program, instead of running the MC program in-house, so as to achieve cost efficiency. The above presented findings (e.g., the ways to solve double marginalization) presented therefore provide a good reference to the MC fashion retailers who have outsourced production activities of their products to an external manufacturer.

5. Fashion Mass Customization Supply Chains with Different Salvage Values of Consumer Returns and Unsold Inventories

Given the popularity of the consumer returns policy in the MC program and the public wave of "environmental sustainability", this chapter extends Chapter 4 by establishing the MC supply chain with different salvage values of consumer returns (i.e., the used items) and unsold leftovers (i.e., unused basic products), and devoting to investigating (i) the efficiency of supply chain contracts in enhancing the performance of the whole channel under this new assumption, (ii) the profit risk analysis on the new MC system, (iii) systems enhancement schemes such as technology investment, product design improvement and the standardization of product components.[28]

5.1 Model formulation

The sequence of events and the decision-making process are similar to Chapter 4 expect three differences.[29] The first difference is that the ordering cost for the basic items are the same under Time 0 and Time 1, i.e., $c_1 = c_0 = c$. Secondly, there is no additional mass-customization cost for these MC products (i.e., $k = \alpha = 0$) since the customization changes are assumed to be minor and simple in this chapter, which can be easily conducted by the fashion retailer himself. Such MC programs can be observed from the real world like the soccer jersey MC programs in the fashion industry and MC schemes in electronic products (e.g. iPads in Apple). Then the third difference is that at the end of the selling season, the fashion retailer salvages the unused basic products at a unit value of v_{UU} and the consumer returned products with a unit value of v_{CR}, both of which can be further processed or remanufactured. This is non-trivial because as we will see

[28] As a remark, most part of this chapter is published in Guo et al., (2018a).
[29] Notice that the mathematical notation and symbols are consistently used in this chapter only, i.e., they may have different meanings in Chapter 4.

later on, these salvage values relate to different industrial measures and the supply chain can be improved by taking some new enhancement schemes. As a remark, to avoid trivial cases, throughout this thesis, we assume that $p > c > m > v_{UU} > v_{CR}$[30]. In the meanwhile, λ is also constrained by the condition of $p - \lambda p + \lambda v_{CR} > c$ in order to guarantee the profit margin of the MC product (under the consideration of consumer returns) is bigger than the unit ordering cost, which means a profitable business for the MC program[31].

Then on the basis of the extended model introduced above, we have the profits of the fashion retailer and the upstream manufacturer as follows:

(1) From the perspective of the fashion retailer:

The profit function of the retail brand can be derived as:

$$\pi_{r,i}(q) = p\min(x,q) - cq + v_{UU}\max(q-x,0) - \lambda p\min(x,q) + v_{CR}(\lambda\min(x,q)),\ i=0,\ 1. \tag{5.1}$$

The expected profit of the retailer is:

$$E[\pi_{r,i}(q)] = [(1-\lambda)p + v_{CR}\lambda - c]q - [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\int_{-\infty}^{q}(q-x)f(x)dx.$$

For the fashion retailer, it aims to find an optimal ordering quantity q_i^{R*} to maximize his own expected profit, and the corresponding optimization problem can be written as:

$$\max_q E[\pi_{r,i}(q)],\ i=0,\ 1.$$

(2) From the perspective of the upstream manufacturer:

As the Stackelberg follower, the upstream manufacturer produces basic items according to the ordering quantity received from the fashion retailer with a

30 It is reasonable to assume that the salvage value of the unsold product is bigger than the salvage value of the consumer returned product since the value of a product should be reduced after use. Furthermore, since in practice the consumer returns under MC are always with customization, it is more difficult to be resold, which is not the case for those unsold products.

31 Under this assumption, $p - \lambda p + \lambda v_{CR}$ is the unit profit margin when there are consumer returns for the MC program, and c is the unit wholesale price paid by the retailer to the upstream manufacturer. In this expression, when there are no consumer returns, i.e., $\lambda = 0$, the unit product's profit margin of the fashion retailer is exactly p. It is a reasonable assumption since the unit product's profit margin of the fashion retailer must be bigger than the unit wholesale price (i.e., the unit ordering cost) paid to the manufacturer in order to ensure that the final unit profit is positive (i.e., larger than 0); otherwise, the MC program will not be launched at all.

negotiated wholesale price. The manufacturer will maximize its expected profit: $E[\pi_{m,i}(q)] = (c-m)q$.

5.2 Decisions in the Centralized and Decentralized Settings: The Comparisons

5.2.1 Decisions in the Centralized Setting

In this section, we also first explore the centralized setting to act as a benchmark so that we can develop the systems optimization scheme for supply chain coordination in the decentralized setting.

Under the centralized model, the profit functions of the whole channel can be derived based on the expected profits of the fashion retailer and the upstream manufacturer that we have discussed in Section 5.1.

Since $\pi_{sc}(q) = \pi_r(q) + \pi_m(q)$, it is straightforward to show that the following is the expected profit of the supply chain system:

$$E\left[\pi_{SC,i}^{C}(q)\right] = [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\mu_i - (m - v_{UU})q + [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\int_q^{+\infty}(q-x)f(x)dx, \quad (5.2)$$

The optimization problem of the whole supply chain is hence shown as follows: $\max_q E\left[\pi_{SC,i}^{C}(q)\right]$, *i=0, 1.*

Then, following the newsvendor model and using the first order condition, it can be observed that the optimal ordering quantity, which maximizes the expected profit of the whole supply chain, is:

$$q_i^{C*} = \mu_i + \sqrt{d_i + \delta}F^{-1}\left(\frac{(1-\lambda)p + v_{CR}\lambda - m}{(1-\lambda)p + v_{CR}\lambda - v_{UU}}\right); \quad (5.3)$$

where $s_i^{C*} = \frac{(1-\lambda)p + v_{CR}\lambda - m}{(1-\lambda)p + v_{CR}\lambda - v_{UU}} = s^{C*}$ is the optimal inventory fill-rate under the centralized setting.

5.2.2 Decisions in the Decentralized Setting

By following the same logic as Chapter 4, it can be found that:

(1) The profit function of the fashion retailer:

We have the expected profit function of the fashion retailer in the decentralized supply chain setting as:

$E\left[\pi_{r,i}^{R}(q)\right] = [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\mu_i - (c - v_{UU})q - [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\sqrt{d_i + \delta}Z(\frac{q-\mu_i}{\sqrt{d_i+\delta}})$.

The corresponding optimal ordering quantity, which maximizes the expected profit of the fashion retailer, is given as[32]:

$$q_i^{R*} = \mu_i + \sqrt{d_i + \delta}F^{-1}(\frac{(1-\lambda)p+v_{CR}\lambda-c}{(1-\lambda)p+v_{CR}\lambda-v_{UU}}). \quad (5.4)$$

The optimal expected profit function of the fashion retailer under optimal ordering quantity is:

$E\left[\pi_{r,i}^{R*}(q_i^{R*})\right] = [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\mu_i - (c - v_{UU})q_i^{R*} - [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\sqrt{d_i + \delta}Z(F^{-1}(s_i^{R*}))$,

where $s_i^{R*} = \frac{(1-\lambda)p+v_{CR}\lambda-c}{(1-\lambda)p+v_{CR}\lambda-v_{UU}} = s^{R*}$ is the optimal service level in the decentralized setting, which is under the leadership of the fashion retailer.

(2) The profit function of the upstream manufacturer:

Given the fashion retailer's ordering quantity of q_i^{R*}, the expected profit of the upstream manufacturer can be written as:

$E[\pi_{m,i}^{R*}(q_i^{R*})] = (c - m)[\mu_i + \sqrt{d_i + \delta}F^{-1}(\frac{(1-\lambda)p+v_{CR}\lambda-c}{(1-\lambda)p+v_{CR}\lambda-v_{UU}})]$.

5.2.3 Discussions

(1) Comparisons between the Centralized and Decentralized Systems

Similar to Chapter 4, according to the discussion above, it can be seen that no matter under which response strategy, the fashion retailer's optimal ordering quantity is always different from the supply chain's[33].

[32] In this chapter, the "R" in the optimal ordering quantity and the optimal service level refers to the situation when the whole supply chain channel is led by the retail brand.

[33] This is observed based on the comparison between the optimal ordering quantity of the retailer and the optimal ordering quantity of the whole supply chain that we have derived in Section 5.2.1.

(2) Win-Win Condition under the Consideration of Consumer Returns and Unused Inventories

From the supply chain system's perspective, the comparisons of the expected profits of the fashion retailer and the upstream manufacturer (in the decentralized model) between the two different ordering scenarios can help determine whether the QR strategy is beneficial to each individual, i.e., QR may not be necessarily a win-win strategy in all conditions. Therefore, we derive some findings as shown in Property 5.1 and Lemma 5.1.

For a notational purpose, we define the following:

$A = F^{-1}\left(\frac{(1-\lambda)p+v_{CR}\lambda-c}{(1-\lambda)p+v_{CR}\lambda-v_{UU}}\right)$, $\Omega = (1-\lambda)p + v_{CR}\lambda - v_{UU}$,

$\varepsilon(\lambda) = -\frac{dA(\lambda)}{d\lambda}, \tau(\lambda) = \frac{dA}{d\lambda}, \ \tau(v_{CR}) = \frac{dA}{dv_{CR}}, \ \tau(v_{UU}) = \frac{dA}{dv_{UU}}$;

$EPQR_r^R = E\left(\pi_{r,1}^{R*}(q_1^{R*})\middle|\mu_1\right) - E\left(\pi_{r,0}^{R*}(q_0^{R*})\right) = (\sqrt{d_0+\delta} - \sqrt{d_1+\delta})\Omega f((F^{-1}(s^{R*}))$;

$EPQR_m^R = E\left(\pi_{m,1}^{R*}(q_1^{R*})\middle|\mu_1\right) - E\left(\pi_{m,0}^{R*}(q_0^{R*})\right) = -(\sqrt{d_0+\delta} - \sqrt{d_1+\delta})(c - m)F^{-1}(s^{R*})$;

$EPQR_{SC}^R = EPQR_r^R + EPQR_m^R$.

The condition of win-win scenario is explored in the following, which refers to the case when both the fashion retailer and the upstream manufacturer are benefited after adopting QR.

Define: $\underline{\lambda} = \frac{p-2c+v_{UU}}{p-v_{CR}}$, $\overline{\lambda} = \frac{p-c}{p-v_{CR}}$.

We first present Property 5.1 (which is found by directly checking the expressions of $EPQR_r^R$ and $EPQR_m^R$) and then Lemma 5.1.

Property 5.1. $EPQR_r^R$ and $EPQR_m^R$ *are both positive if and only if the consumer returns rate* λ *is bounded between* $\underline{\lambda}$ and $\overline{\lambda}$.

Lemma 5.1. *Under the adoption of quick response, the salvage value of unused inventories and the salvage value of consumer returns have opposite effects on the* *chance of achieving a win-win outcome for the whole supply chain system.*

Lemma 5.1 shows an interesting result regarding the impacts brought by the salvage values. If we look into the technical details, we can see that an increase in the salvage value of the unused items will lead to an increase in $\underline{\lambda}$ (the lower bound of consumer returns rate for win-win) while keep the upper bound $\overline{\lambda}$ the same, which consequently reduces the flexibility of consumer returns rate in achieving a win-win outcome. Similarly, when the salvage value of consumer returns decreases, the range also becomes smaller. Therefore, an increase of the salvage value of unused leftovers or a decrease of the salvage value of consumer returns will decrease the likelihood of achieving a win-win result.

(3) Comparisons on the Effects of Consumer Returns and Unused Inventories

From the analytical EPQR expressions of different members, it is possible that the consumer returns and unused inventories may have different effects on the EPQR of each supply chain member, and the difference is summarized in Corollary 5.1 and Corollary 5.2.

Corollary 5.1. *(a)* $\boldsymbol{EPQR_m^R}$ *is monotonically decreasing in* $\boldsymbol{v_{CR}}$*; (b) i) Necessary and sufficient condition:* $\boldsymbol{EPQR_r^R}$ *is increasing in* $\boldsymbol{v_{CR}}$ *if and only if* $\boldsymbol{\lambda > \Omega A \tau(v_{CR})}$*;* $\boldsymbol{EPQR_r^R}$ *is decreasing in* $\boldsymbol{v_{CR}}$ *if and only if* $\boldsymbol{\lambda < \Omega A \tau(v_{CR})}$*; ii) Sufficient condition: When* $\frac{c-(1-\lambda)p}{\lambda} < v_{CR} < \frac{2c-(1-\lambda)p-v_{UU}}{\lambda}$*,* [34] $\boldsymbol{EPQR_r^R}$ *is increasing in* $\boldsymbol{v_{CR}}$*; (c) Necessary and sufficient condition:* $\boldsymbol{EPQR_{SC}^R}$ *is increasing in* $\boldsymbol{v_{CR}}$ *if and only if* $\boldsymbol{\lambda - \Omega A \tau(v_{CR}) > \frac{(c-m)\tau(v_{CR})}{f(A)}}$*;* $\boldsymbol{EPQR_{SC}^R}$ *is decreasing in* $\boldsymbol{v_{CR}}$ *if and only if* $\boldsymbol{\lambda - \Omega A \tau(v_{CR}) < \frac{(c-m)\tau(v_{CR})}{f(A)}}$.

Corollary 5.1 shows the fact that from the perspective of the upstream manufacturer, a higher salvage value of consumer returns will reduce the benefits gained from QR. It is reasonable since a higher salvage value of consumer returns means a lower expected loss of offering the consumer returns policy for MC (e.g.,

[34] It is the case when the optimal inventory service level of the retail brand $s^{R*} < 0.5$.

Nike and Shoe of Prey). The information collected from the time stage that is closer to the selling season, which is about the specific customer needs, also becomes not as crucial as in the case when the salvage value of consumer returns is low. Consequently, the expected value of quick response depresses. As for the fashion retailer, when the loss induced by the consumer returns rate is big enough, i.e., $\boldsymbol{\lambda > \Omega A \tau(v_{CR})}$, it will definitely benefit from an increased salvage value of consumer returns owing to the reduced overall loss. That is, the higher possibility of having consumer returns, the more important the salvage value of consumer returns becomes. It is also the case for the whole MC supply chain. Therefore, it is necessary to consider the consumer returns' salvage value when investigating the performance of QR for MC.

Corollary 5.2. *(a)* $\boldsymbol{EPQR_m^R}$ *is monotonically decreasing in* $\boldsymbol{v_{UU}}$*; (b) i) Necessary and sufficient condition:* $\boldsymbol{EPQR_r^R}$ *is increasing in* $\boldsymbol{v_{UU}}$ *if and only if* $\boldsymbol{\Omega A \tau(v_{UU}) < -1}$*;* $\boldsymbol{EPQR_r^R}$ *is decreasing in* $\boldsymbol{v_{UU}}$ *if and only if* $\boldsymbol{\Omega A \tau(v_{UU}) > -1}$*; ii) Sufficient condition: When* $\boldsymbol{2c - (1-\lambda)p - \lambda v_{CR} < v_{UU} < m}$*,* [35] $\boldsymbol{EPQR_r^R}$ *is decreasing in* $\boldsymbol{v_{UU}}$*; (c) i) Necessary and sufficient condition:* $\boldsymbol{EPQR_{SC}^R}$ *is increasing in* $\boldsymbol{v_{UU}}$ *if and only if* $\boldsymbol{-f(A) - (c-m)\tau(v_{UU}) > \Omega A f(A) \tau(v_{UU})}$*;* $\boldsymbol{EPQR_{SC}^R}$ *is decreasing in* $\boldsymbol{v_{UU}}$ *if and only if* $\boldsymbol{-f(A) - (c-m)\tau(v_{UU}) < \Omega A f(A) \tau(v_{UU})}$*; ii) Sufficient condition: When* $\boldsymbol{2c - (1-\lambda)p - \lambda v_{CR} < v_{UU} < m}$*,* $\boldsymbol{EPQR_{SC}^R}$ *is decreasing in* $\boldsymbol{v_{UU}}$*.*

Corollary 5.2 indicates that the salvage value of unused inventories has a negative impact on the upstream manufacturer's EPQR. It is intuitive as a higher salvage value of unused inventories means a lower level of loss for holding leftover inventories, which substantially reduces the importance of information updating about the market demand (i.e. QR) when making quantity preparation for

[35] It is the case when the optimal inventory service level of the retail brand $s^{R*} > 0.5$.

the basic items. Similarly, when the salvage value of unused inventories is sufficiently high, i.e., high enough to make the inventory service level larger than 0.5, both the fashion retailer and the MC supply chain will also reduce the EPQR if the salvage value of those unused items continues to increase. From the above discussions, it can be seen that the salvage value of unused inventories can directly influence both the preferences of the manufacturer and the fashion retailer on QR. Therefore, the consideration of unused inventories' salvage value is critical for managing QR in MC supply chains efficiently.

5.3 Win-Win Coordination

From Section 5.2, it can be seen that the supply chain system is not guaranteed to be coordinated and in fact, a win-win situation for the supply chain members need not appear after they have implemented QR. We hence explore the contractual arrangement which can achieve win-win coordination in this section.

To achieve win-win coordination, one would think about the use of a powerful yet simple supply contract. The candidate which appears naturally would be the two-part tariff contract which is capable of coordinating many supply chains in the presence of double marginalization problem. Under the two-part tariff contract (c', A), the profit functions of the fashion retailer and the upstream manufacturer can be listed as follows:

$$E\left[\pi_{r,1}^{T}(q)\right] = [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\mu_1 - (c' - v_{UU})q - [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\sqrt{d_1+\delta}Z\left(\frac{q-\mu_1}{\sqrt{d_1+\delta}}\right) - A;$$

$$E\left[\pi_{m,1}^{T}(q)\right] = (c' - m)q + A.$$

Correspondingly, the fashion retailer's new optimization problem is:

$$\max_{q_1} E\left[\pi_{r,1}^{T}(q_1(c',A))\right].$$

At the same time, the objective of the upstream manufacturer is to ensure: $E\left[\pi_{r,1}^{T}\left(q_1(c',A)\right)\right] > E\left(\pi_{r,0}^{R*}(q_0^{R*})\right)$ and $E\left[\pi_{m,1}^{T}(q_1(c',A))\right] >$

$E\left(\pi_{m,0}^{R*}(q_0^{R*})\right)$, given the negotiated wholesale price c' as well as the condition of $q_1^{T*}(c',A) = q_1^{C*}$ (i.e. achieving coordination).

However, Lemma 5.2 shows the result that the two-part tariff contract has very limited flexibility in achieving win-win coordination.

Lemma 5.2. *When* $0 < \lambda < \frac{p-2c+v_{UU}}{p-v_{CR}}$ *and* $EPQR_{SC}^{T} > 0$ *, the win-win coordination be achieved by the two-part tariff supply contract (with wholesale price* c' *and fixed credit transfer A) if and only if* $c' = m$*, and A in the range of*

$(c-m)[\mu_0 + \sqrt{d_0+\delta}F^{-1}(s^{R*})] < A < (c-m)\mu_0 + \Omega[\sqrt{d_0+\delta}f\left(F^{-1}(s^{R*})\right) - \sqrt{d_1+\delta}f(F^{-1}(s^{C*}))]$.

Lemma 5.2 indicates that only when the upstream manufacturer agrees to set his wholesale price that is sufficient enough to cover his manufacturing cost, will win-win coordination be achieved by a two-part tariff contract, which reveals the limitation of a two-part tariff contract in achieving win-win coordination when the consumer returns are considered and the salvage values of consumer returns and leftovers are different. In fact, given this complex channel structure, the limitation also appears to other simple supply chain contracts. For instance, if the adopted contract is a buyback contract (or a markdown contract), adjusting the buyback price (or the markdown price) can only guarantee the ordering quantity chosen by the fashion retailer is optimal for the supply chain while either of the members may still suffer. As a consequence, a hybrid contract is needed to improve the performance of the MC supply chain even when the upstream manufacturer is not willing to charge such a low wholesale price since it is risky. In fact, the superiority of a hybrid contract is also proved by other literature such as Liu et al. (2006), although the hybrid contract proposed in this section is different from Liu et al. (2006).

Considering the existence of double marginalization, a hybrid contract combining the decisions in a differentiated buyback contract and a two-part tariff contract is designed in this section. Under this contract, the upstream manufacturer agrees to buyback all of the leftover items and consumer returns from the fashion retailer at the end of the selling season on the basis of their respective salvage values. That is, the manufacturer will buyback the unused basic items with a buyback price of θv_{UU} and the consumer returns with a buyback price of θv_{CR}[36]. To eliminate arbitrage value of the products returned by the retailer, it is assumed that $\theta > 1$ and $0 < \theta v_{CR} < \theta v_{UU} < m$. Besides, to ensure a profitable business, θ is also bounded by $p - \lambda(p - \theta v_{CR}) > c$. At the same time, the hybrid contract also contains other two parameters, referring to the unit wholesale cost c paid by the fashion retailer for ordering the basic items and a lump-sum fee A paid by the fashion retailer to the upstream manufacturer aiming at compensating the loss of the manufacturer. Notice that in this chapter, we assume that the upstream manufacturer has a same salvage capability as the fashion retailer, which means the two salvage values of leftover items and consumer returns are exactly the same with the situation when salvaged by the fashion retailer[37].

Under the hybrid contract (c, θ, A), the profit functions of the fashion retailer and the upstream manufacturer become:

$$E\left[\pi_{r,1}^{H}(q)\right] = [(1-\lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\mu_1 - (c - \theta v_{UU})q - [(1-\lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\sqrt{d_1+\delta}\,Z\left(\frac{q-\mu_1}{\sqrt{d_1+\delta}}\right) - A,$$

$$E\left[\pi_{m,1}^{H}(q)\right] = [(\theta-1)(v_{UU} - v_{CR}\lambda)]\mu_1 + [c - m - (\theta-1)v_{UU}]q - [(\theta-1)(v_{UU} - v_{CR}\lambda)]\sqrt{d_1+\delta}\,Z\left(\frac{q-\mu_1}{\sqrt{d_1+\delta}}\right) + A.$$

Then the fashion retailer's new optimization problem is:

$$\max_{q_1} E\left[\pi_{r,1}^{H}(q(c,\theta,A))\right].$$

The upstream manufacturer sets the contract parameters to achieve:

$$E[\pi_{r,1}^{H}(q(c,\theta,A))] > E\left(\pi_{r,0}^{R*}(q_0^{R*})\right),\ E[\pi_{m,1}^{H}(q(c,\theta,A))] > E\left(\pi_{m,0}^{R*}(q_0^{R*})\right)],$$

and $q_1^{H*}(c,\theta,A) = q_1^{C*}$. Define:

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36 The upstream manufacturer is supposed to have the capability to distinguish the consumer returns from unused basic products and to acquire enough information about the final salvage market.

37 It happens when there is a common salvage market or recycle channel. Typical examples are the Amelia's chain, which is a salvage chain in Pennsylvania, and the Liquidity Service Inc.

$\Delta F^{-1}(s) = \big[c - m - (\theta - 1)v_{CR}\lambda - (\theta - 1)(v_{UU} -$

$v_{CR}\lambda)s^{H*}\big]\sqrt{d_1 + \delta}F^{-1}\big(s^{H*}\big) - (c - m)\sqrt{d_0 + \delta}F^{-1}(s^{R*}),$

$\Delta f\big(F^{-1}(s)\big) = [(1 - \lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\sqrt{d_1 + \delta}f\left(F^{-1}\big(s^{H*}\big)\right) -$

$\Omega\sqrt{d_0 + \delta}f\big(F^{-1}(s^{R*})\big).$

Proposition 5.1. *When* $0 < \lambda < \frac{p - 2c + v_{UU}}{p - v_{CR}}$ *and* $EPQR_{SC}^{H} > 0$ *, the MC supply chain can achieve win-win coordination under quick response by utilizing a differentiated buyback policy based two-part tariff contract, with* $\theta = 1 + \frac{\Omega(c-m)}{\lambda m v_{CR} + [(1-\lambda)p - m]v_{UU}}$*, and the parameter* A *in the range of* $\underline{A} < A < \overline{A}$*,, where:*

$\underline{A} = (\theta - 1)v_{CR}\lambda\mu_0 + [(\theta - 1)(v_{UU} - v_{CR}\lambda)]\sqrt{d_1 + \delta}f\left(F^{-1}\big(s^{H*}\big)\right) - \Delta F^{-1}(s);$

$\overline{A} = (\theta - 1)v_{CR}\lambda\mu_0 - \Delta f\big(F^{-1}(s)\big).$

Proposition 5.1 indicates that a policy combines a differentiated buyback mechanism and a two-part tariff mechanism can help achieve win-win coordination for the MC supply chain with unconditional consumer returns in the presence of the quick response strategy. That is, the expected profit of the whole channel is maximized and in the meanwhile, both of the fashion retailer and the upstream manufacturer will choose the quick response strategy since none of them suffers.

Referring to Lemma 5.2 and Proposition 5.1, it can be seen that with the help of the two-part tariff contract and the hybrid contract, both of which relate to the side-payment contract, the QR strategy can always bring more profit than the initial SR case.[38] Notice that, the side-payment contract consists of a major linear transfer function as well as an additional constant monetary transfer and is widely applied in practice for coordination like the consignment contract and the franchising contract. Similar cases with the arbitrary allocation of profit surplus can also be observed from companies like Amazon (e.g., the Pro-merchant

[38] The existence of the lump-sum fee A guarantees that, with the help of these two contracts, the QR strategy is always more preferable than the case without QR for the supply chain. For more details, interested readers can refer to the definition of $EPQR_r$ and $EPQR_m$ as well as the Proofs of Lemma 5.2 and Proposition 5.1 in Appendix C.

program) and 7–11 (Sarker, 2014).

At the same time, given the various challenges in the dynamic market environment, detailed comparison on the performance of these two contracts is also made in Table 5.2, which provides a guideline for the selection between these two contracts when pursuing different objectives. As can be observed from Table 5.2, the hybrid contract outperforms the two-part tariff contract in the flexibility of dividing the channel profit. However, the two-part tariff contract is more favorable in practice than the hybrid contract when the involved players pursue a coordination mechanism which is simpler to be implemented. In addition, under the two-part tariff contract, as the fashion retailer has to pay the manufacturer a guaranteed lumpsum of money, there is essentially no risk for the manufacturer. Thus, the two-part tariff contract also has its strength in the risk aspect. In short, there are strengths and weaknesses associated with the two contracts and hence we propose them for decision makers to choose.

Table 5.2 Comparisons between the Two-Part Tariff Contract and the Hybrid Contract

Category	The two-part tariff contract	The hybrid contract
Profit risk	Lower	Higher
Flexibility of dividing profits	Lower	Higher
Simplicity in practice[39]	Higher	Lower

5.4 Supply Chain Systems Risk Analysis and Numerical Analysis

Considering the high uncertainty in the consumer market, the supply chain inevitably suffers a high level of risk (Asian and Nie, 2014; He et al., 2014). Therefore, risk analysis for the coordinated supply chain system is conducted in this part. We employ the variance of profit of the whole channel under a centralized supply chain structure as a measure of risk. Notice that this approach follows the classic Nobel prize awarded mean-variance (MV) theory (Markowitz, 1959) and

[39] This is an observation from the perspective of the whole channel.

has been widely adopted by various supply chain optimization studies such as Choi and Chow (2008), Shen et al. (2013), Li et al. (2014), and Choi (2016).

From the standpoint of the MC supply chain, the variance of profit at q_i^{C*}, *i=0, 1,* is: $\mathrm{V}\left(\pi_{sc,i}\left(q_i^{C*}\right)\right) = \Omega^2(d_i + \delta)\xi(F^{-1}(s^{C*}))$.

Define the following and we have Lemma 5.3.

$A' = F^{-1}\left(\frac{(1-\lambda)p+v_{CR}\lambda-m}{(1-\lambda)p+v_{CR}\lambda-v_{UU}}\right),\ \omega(\lambda) = \frac{dA'}{d\lambda},\ \omega(v_{CR}) = \frac{dA'}{dv_{CR}},\ \omega(v_{UU}) = \frac{dA'}{dv_{UU}}.$

Lemma 5.3. (*a*) $\boldsymbol{V}\left(\boldsymbol{\pi}_{sc,i}\left(\boldsymbol{q}_i^{C*}\right)\right)$ *is decreasing in* $\boldsymbol{\lambda}$ *if and only if* $\boldsymbol{\xi}(\boldsymbol{A}') < \frac{\Omega\frac{d\xi(A')}{d(A')}\omega(\lambda)}{2(p-v_{CR})}$; *(b)* $\boldsymbol{V}\left(\boldsymbol{\pi}_{sc,i}\left(\boldsymbol{q}_i^{C*}\right)\right)$ *is increasing in* $\boldsymbol{v_{CR}}$; *(c)* $\boldsymbol{V}\left(\boldsymbol{\pi}_{sc,i}\left(\boldsymbol{q}_i^{C*}\right)\right)$ *is decreasing in* $\boldsymbol{v_{UU}}$ *if and only if* $\boldsymbol{\xi}(\boldsymbol{A}') > \frac{\Omega\frac{d\xi(A')}{dA'}\omega(v_{UU})}{2}$.

As shown in Lemma 5.3, when there is a change on the consumer returns rate, the salvage value of the consumer returns, or the salvage value of the leftover products, the variance of profit of the whole supply chain system under two ordering time stages will also change. In Lemma 5.3, even though the specific increasing/decreasing situation is associated with a condition, as we will see in Section B, the condition is basically satisfied.

In the following, the numerical analysis is conducted to better illustrate the impacts of consumer returns and unused inventories on the variance of profit of the MC supply chain system in the quick response scenario.[40] We consider the input values of the related parameters are p = 37.5, c = 12.5, m = 5, v_{UU}=1.5, v_{CR}=0.8, μ_0=35, d_0=100, δ=25, λ=0.38. As a remark, these numerical values are set by referring to other relevant papers such as Choi and Chow (2008), Chen (2011), Chow et al., (2012), and Liu et al., (2014), and they satisfy the basic assumptions of the model explored in this paper. For instance, for the salvage value of consumer returns and the unused basic products, we set the values within the ranges of $p > c > m > v_{UU} > v_{CR}$ and $p - \lambda p + \lambda v_{CR} > c$, as we have

[40] Readers interested in the numerical analysis of variance of profit of the MC supply chain in the slow response case can refer to Appendix C2 for more details.

discussed in Section 5.1. In addition, to ensure the reliability of our numerical analysis, we have explored various scenarios with different values for the parameters and we have also set the four scenarios with different salvage values of consumer returns and salvage values of unused items (see the online supplementary file). In order to specifically show the independent effects of these three aspects, we change the value of λ, v_{CR} and v_{UU}, respectively. As the results are all similar, to avoid duplication, we only show the case with one scenario.

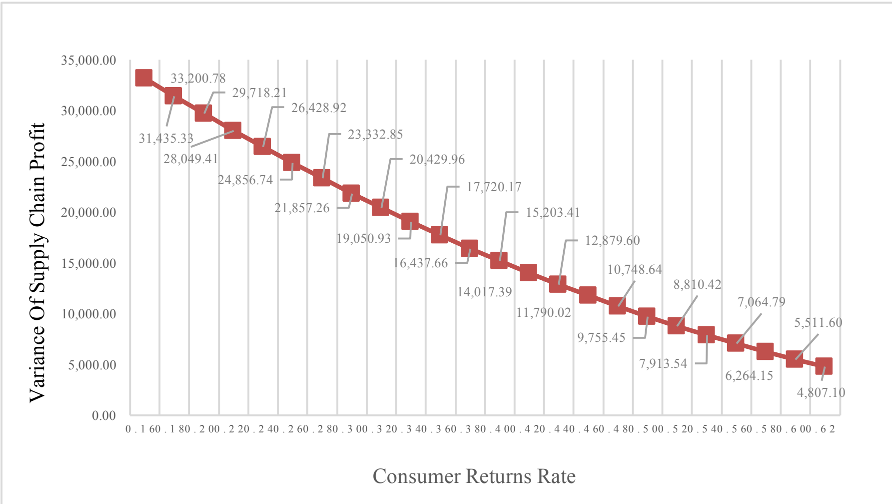

Figure 5.1 The variance of supply chain profit plotted against the consumer returns rate

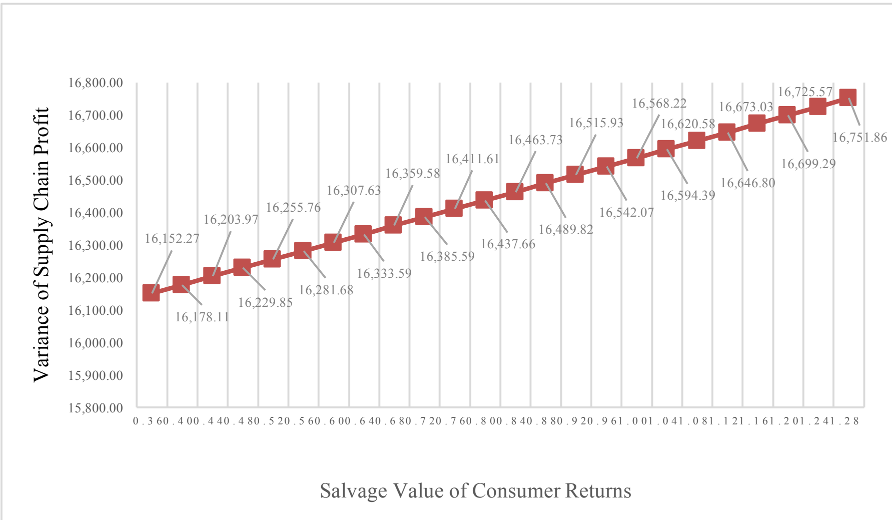

Figure 5.2 The variance of supply chain profit plotted against the salvage value of consumer returns

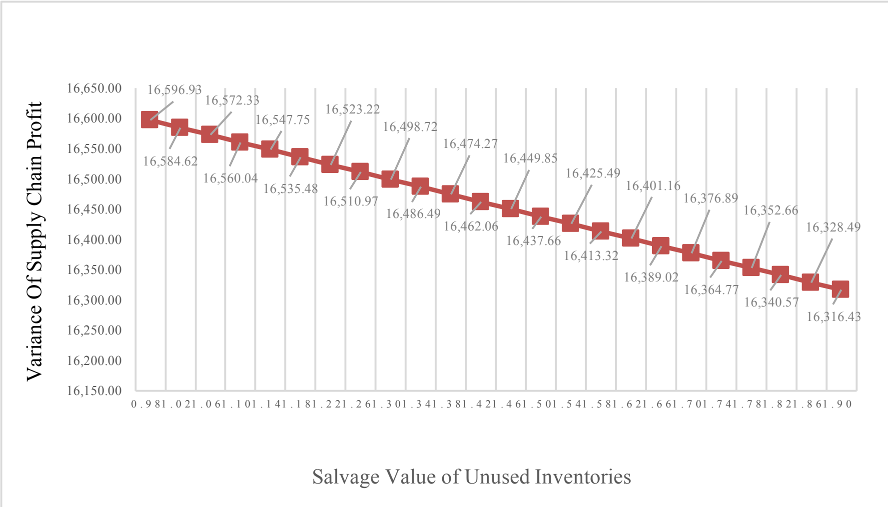

Figure 5.3 The variance of supply chain profit plotted against the salvage value of unused product

By referring to all tables that are provided in the Appendix C2, it can be found that the variance of profit is always much lower in the quick response case than the slow response counterpart. Besides, from Figure 5.1, we can see that the supply chain's profit variance is decreasing in the consumer returns rate. The drop is also very obvious and exhibits a quadratic pattern. It is reasonable that when the consumer returns rate is very low, it is difficult to forecast the final quantity of consumer returns, which consequently increases the uncertainty of the profit. However, if the consumer returns ratio is high, it becomes easier for the whole channel to estimate the final consumer returns quantity and make corresponding preparation for dealing with these returns so as to maximize the channel's profit.[41] From Figure 5.2, when the salvage value of consumer returns increases, the supply chain's profit variance increases. The rate of increase is linear. Finally, from Figure 5.3, we find that when the salvage value of unused item increases, the supply chain's profit variance decreases. The change is also linear. As a consequence, since the supply chain's profit variance represents the level of supply chain risk,

[41] Notice that the extreme case when the consumer returns rate is equal to 1 is not considered in this paper since it means a business collapse, which will not happen in practice. Thus, the profit uncertainty, i.e., the risk, can never be totally avoided.

Figures 5.1 to 5.3 indicate various important findings. First, for the salvage values, a lower salvage value of consumer returns and a higher salvage value of unused item would lead to a lower level of supply chain risk. Second, counter-intuitively, if the consumer returns rate is higher, the profit uncertainty is actually lower which means the level of risk is lower. This is an interesting situation.

5.5 Systems Enhancement Measures

According to the supply chain risk analysis and the discussion in previous sections, it can be observed that the consumer returns rate, the salvage values of both the unsold inventories and consumer returns can substantially influence the performance of the MC program, no matter from the perspective of the expected value of the quick response strategy or the variance of the MC supply chain's profit. Therefore, in the following, we discuss several methods to improve the MC supply chain from these three aspects by using various industrial approaches, namely technology investment, product design improvement, and standardization of component.[42] Note that these measures all incur a certain sunk cost which is taken as a fixed cost (for a long time operation) and shared among products, etc. Thus, the cost per product per period is negligible and being ignored in the model.

5.5.1 Technology Investment

(1) Analytical investigation

MC is a technology driven measure. It is understood that if the supply chain members are willing to enhance the MC process by investing in technologies, quality of the MC process and product will both be improved. For instance, the MC program may encounter some feature incompatibilities owing to the increased variability problem (Heradio et al., 2016). The investment in developing automated supporting tools to help identify those incompatible features can efficiently improve the quality of the mass customized products, which can

[42] As a remark, most industrial measures proposed in Section 5.5 are published in Guo et al. (2018b).

consequently contribute to the decrease of consumer returns percentage. Apart from this, the MC supply chain can also enhance the MC process by following the multistage manufacturing systems emphasized in Du et al. (2016) or introducing some intelligent systems, such as the hybrid OLAP-association rule mining based quality management system[43] (Lee et al., 2013).

In short, with proper technology investment, the quality of the MC products will be enhanced, and consequently the proportion of consumer returns will be reduced ($\tilde{\boldsymbol{\lambda}} < \boldsymbol{\lambda}$). In this sub-section, we examine the impacts brought by this action.

Define:

$$A'' = F^{-1}\left(\frac{(1-\lambda)p+\theta v_{CR}\lambda-c}{(1-\lambda)p+\theta v_{CR}\lambda-\theta v_{UU}}\right),\ \gamma(\lambda) = \frac{dA''}{d\lambda},\ \gamma(v_{CR}) = \frac{dA''}{dv_{CR}},\ \gamma(v_{UU}) = \frac{dA''}{dv_{UU}}.$$

$$k(\lambda) = (\theta-1)\big(v_{CR} + (v_{UU} - v_{CR}\lambda)A''\gamma(\lambda)\big) - \frac{\mathrm{d}\theta}{\mathrm{d}\lambda}(v_{UU} - v_{CR}\lambda),$$

$$k(v_{CR}) = (\theta-1)\big(\lambda + (v_{UU} - v_{CR}\lambda)A''\gamma(v_{CR})\big) - \frac{\mathrm{d}\theta}{\mathrm{d}v_{CR}}(v_{UU} - v_{CR}\lambda),$$

$$k(v_{UU}) = (\theta-1)\big(-1 + (v_{UU} - v_{CR}\lambda)A''\gamma(v_{UU})\big) - \frac{\mathrm{d}\theta}{\mathrm{d}v_{UU}}(v_{UU} - v_{CR}\lambda).$$

Then we have Lemma 5.4.

Lemma 5.4.

(a) If these two consumer returns rates (i.e., $\tilde{\boldsymbol{\lambda}}$, $\boldsymbol{\lambda}$) are in the range of $(\boldsymbol{p} - \boldsymbol{v_{CR}})\boldsymbol{f}(\boldsymbol{A}) + [\boldsymbol{\Omega A f}(\boldsymbol{A}) + \boldsymbol{c} - \boldsymbol{m}]\boldsymbol{\tau}(\boldsymbol{\lambda}) > \frac{(\boldsymbol{p}-\boldsymbol{v_{CR}})\boldsymbol{\mu_i}}{\sqrt{\boldsymbol{d_i}+\boldsymbol{\delta}}}$*, the expected profit of the entire chain is increased by increasing the technology investment in the MC process; (b) From the view of the whole channel, the expected value of quick response is increased if and only if both of these two $\boldsymbol{\lambda}$ can satisfy* $\boldsymbol{\Omega A f}(\boldsymbol{A}) + (\boldsymbol{c} - \boldsymbol{m}) < \frac{(\boldsymbol{p}-\boldsymbol{v_{CR}})\boldsymbol{f}(\boldsymbol{A})}{\boldsymbol{\varepsilon}(\boldsymbol{\lambda})}$*; (c) Under the win-win coordination contact, the lower bound for win-win outcome is reduced if both of the new and updated $\boldsymbol{\lambda}$ satisfy* $\frac{\boldsymbol{d\Delta F^{-1}}(s)}{\boldsymbol{d\lambda}} + \boldsymbol{k}(\boldsymbol{\lambda})\sqrt{\boldsymbol{d_1} + \boldsymbol{\delta}}\boldsymbol{f}(A'') - \frac{\boldsymbol{d\theta}}{\boldsymbol{d\lambda}}\boldsymbol{v_{CR}\lambda\mu_0} < (\boldsymbol{\theta} - \boldsymbol{1})\boldsymbol{v_{CR}\mu_0}$ *, and the upper*

[43] This is a data mining system which can help extract defect patterns from various products.

bound for win-win outcome is increased if these two $\boldsymbol{\lambda}$ *satisfy* $\frac{d\Delta f\left(F^{-1}(s)\right)}{d\lambda} - \frac{d\theta}{d\lambda}v_{CR}\lambda\mu_0 > (\theta - 1)v_{CR}\mu_0$*; (d) The risk of the entire chain is increased if* $\xi(A') < \frac{\Omega\frac{d\xi(A'))}{dA'}\omega(\lambda)}{2(p-v_{CR})}$.

As indicated in Lemma 5.4, the investment in technology (e.g., dominant MC retailers like Nike may offer some financial support for the contracted manufacturers to improve their production and manufacturing technologies) not only can increase the expected profit of the entire supply chain, but also increase the significance of quick response for the supply chain (by increasing the expected value of quick response). In the meantime, the difficulty in achieving win-win coordination can also be reduced if the respective conditions are satisfied. However, the profit variance is very likely increased, which means the level of risk is higher since this requires extra financial support for the MC programs.

(2) Industrial Measures

Since personalization is the main difference with the traditionally mass production environment, great attention should also be paid to the target consumers from the initial product design stages to the final product delivery process. Several technology improvement measures, which supplements the above discussion in the analytical investigation, are proposed below to help reduce the consumer returns rate:

a) Flexible Manufacturing Systems (FMS): This is a system made up of different program modules and can repeat the manufacturing sequences across various products (Duray et al., 2000). It is efficient in reducing the MC cost while satisfying the consumer needs, which is emphasized by MC papers such as Squire et al., (2006), and Dean et al., (2009). One real case of FMS is Levi Straus' custom-fit jeans.

b) Service-Oriented Architecture (SOA): Under this technology, the involved members can interactively share various sub-functions in a flexible way and therefore it provides a dynamic framework for product development in the MC game, which is suggested in MC related papers like Karpowitz et al., (2008).

c) Computer-Aided-Design (CAD): This technique can perform MC functions in a much more rapid and accurate manner based on the automatic made-to-measure processes. For instance, the wydiwyg.co.uk website offers a simple CAD design program to its MC customers, by which the customers can directly create their own designs without any extra help from a third party (Bateman and Cheng, 2006).

d) Enterprise Resource Planning (ERP): It is a system holds excellent information processing abilities, in which all related data is simultaneously shared among different entities in the system without any information delay or distortion (Akkermans et al., 2003). This system can feasibly translate individual MC customer's needs as well as preference into detailed products specifications (Zhao and Fan, 2007).

e) Collaborative quality control approach: Since it is difficult to have direct control on the very complex and dynamic MC system, increasing the cooperation between different subsystems that have interaction with each other can improve the performance of the entire system and consequently guarantee a higher quality of the MC products (Tseng et al., 1997). For example, the collaborative factory automation system proposed by Leitao et al., (2005) can be adopted to control the manufacturing process and consequently supervise the whole quality of MC merchandise.

5.5.2 Product Design Improvement

(1) Analytical investigation

From the perspective of improving the value of consumer returned products, it is important to consider from the product design perspective to see if the MC product can be, e.g., design in a modular format in which different components can be decomposed as "modules" that could be used for the production of other products, i.e., designs its products in a way that is easier to decompose (Li et al., 2016;

Schöggl et al., 2017). If yes, then the salvage value of the consumer returned items will be higher ($\widetilde{v_{CR}} > v_{CR}$). From this perspective, we have Lemma 5.5.

Lemma 5.5.

(a) If these two salvage values of consumer returns (i.e., $\widetilde{\boldsymbol{v_{CR}}}$, $\boldsymbol{v_{CR}}$) are in the range of $\boldsymbol{\lambda f(A) - [\Omega A f(A) - c + m]\tau(v_{CR}) < \frac{\lambda \mu_i}{\sqrt{d_i + \delta}}}$*, the expected profit of the whole channel is increased by designing the MC products in a way that is easier to decompose*; *(b) From the view of the whole channel, the expected value of quick response is increased if and only if both of these two* $\boldsymbol{v_{CR}}$ *can satisfy* $\boldsymbol{\lambda - \Omega A \tau(v_{CR}) > \frac{(c-m)\tau(v_{CR})}{f(A)}}$; *(c) Under the win-win coordination contact, the lower bound for win-win outcome is reduced if both of the new and updated* $\boldsymbol{v_{CR}}$ *satisfy* $\boldsymbol{\frac{\mathrm{d}\Delta F^{-1}(s)}{dv_{CR}} + k(v_{CR})\sqrt{d_1 + \delta} f(A'') - \frac{\mathrm{d}\theta}{dv_{CR}} v_{CR} \lambda \mu_0 > (\theta - 1)\lambda \mu_0}$*, and the upper bound for win-win outcome is increased if these two* $\boldsymbol{v_{CR}}$ *satisfy* $\boldsymbol{\frac{\mathrm{d}\Delta f\left(F^{-1}(s)\right)}{\mathrm{d}v_{CR}} - \frac{\mathrm{d}\theta}{\mathrm{d}v_{CR}} v_{CR} \lambda \mu_0 < (\theta - 1)\lambda \mu_0}$; *(d) The risk of the entire chain is increased.*

Similar to the case of technology investment in the MC process, the improvement in product design is also shown to be effective in increasing the expected profit of the entire chain, as well as the expected values of quick response of the MC supply chain. It is also helpful in decreasing the difficulty in attaining win-win coordination. However, the level of risk faced by the supply chain system is higher.

(2) Industrial Measures

The enhancement of the consumer returns' salvage value can be realized by product design improvement methods, the details of which are presented as follows.

a) Reconfiguration flexibility: This is a term refers to the ability to reconfigure the returned items from the consumer market, the degree of which is a function of the product specification that happens at an upstream level (Brabazon et al., 2010).

That is, if the producers of MC products can take advantage of their upstream supply, planning, and production networks to design the customized items in a highly reconfigurable way, then the MC products will be more adaptable to the external changes as well as further remanufacturing or reengineering activities. As a result, consumer returns' salvage value can be largely improved and finally the MC profits can also be lifted.

b) New materials: Nanotechnology, for instance, is a technology that can be utilized for creating new MC materials or MC products like smart polymers in materials and the nanochips as well as nanosensors in electronical items (Tien, 2011). It is undoubtedly with high efficiency in making MC products cleaner and achieving higher quality. In addition, this is also in line with the existing policies in some MC brands like Nike[44], the material policies of which have emphasized the utilization of nanotechnology materials.

c) *Information sharing*: Sharing the knowledge of the future remanufacturing or reengineering options, e.g., through the cloud computing service provided by IBM, Microsoft and Google, can be an efficient guidance to the designers of the MC products, can ensure a higher possibility of the basic configuration of the personalized products to be further processed or remanufactured.

5.5.3 Standardization of Component

(1) Analytical investigation

In the MC supply chain that we investigated, the unused standard semi-finished (i.e. un-customized) product can actually be used to produce other products if the supply chain has considered it in its product development and planning processes. That is, if the unused standard semi-finished product can be created in a way that is easier to be used as a component of another product, the salvage value of them will be higher ($\widetilde{\boldsymbol{v}_{UU}} > \boldsymbol{v}_{UU}$). This leads us to derive Lemma 5.6.

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[44] Related information can be found in Nike's official website https://about.nike.com/pages/chemistry-restricted-substances-list.

Lemma 5.6.

(a) If these two salvage values of the unsold inventories (i.e., $\widetilde{\boldsymbol{v}_{UU}}, \boldsymbol{v}_{UU}$ *) are in the range of* $[\boldsymbol{\Omega A f(A)} + \boldsymbol{c} - \boldsymbol{m}]\boldsymbol{\tau}(\boldsymbol{v}_{UU}) > -\boldsymbol{f}(\boldsymbol{A})$*, the expected profit of the whole channel is increased by designing the basic products in a way that is easier to be used as a component for another product*; *(b) From the view of the whole channel, the expected value of quick response is increased if and only if both of these two* $\boldsymbol{v}_{UU}$ *can satisfy* $-\boldsymbol{f}(\boldsymbol{A}) - (\boldsymbol{c} - \boldsymbol{m})\boldsymbol{\tau}(\boldsymbol{v}_{UU}) > \boldsymbol{\Omega A f}(\boldsymbol{A})\boldsymbol{\tau}(\boldsymbol{v}_{UU})$; *(c) Under the win-win coordination contact, the lower bound for win-win outcome is reduced if both of the new and updated* $\boldsymbol{v}_{UU}$ *satisfy* $\frac{\mathbf{d}\Delta \boldsymbol{F}^{-1}(s)}{\mathbf{d}\boldsymbol{v}_{UU}} + \boldsymbol{k}(\boldsymbol{v}_{UU})\sqrt{\boldsymbol{d}_1 + \boldsymbol{\delta}}\boldsymbol{f}(\boldsymbol{A}'') > \frac{\mathbf{d}\boldsymbol{\theta}}{\mathbf{d}\boldsymbol{v}_{UU}}\boldsymbol{v}_{CR}\boldsymbol{\lambda}\boldsymbol{\mu}_0$ *, and the upper bound for win-win outcome is increased if these two* $\boldsymbol{v}_{UU}$ *satisfy* $\frac{\mathbf{d}\Delta \boldsymbol{f}\left(\boldsymbol{F}^{-1}(s)\right)}{\mathbf{d}\boldsymbol{v}_{UU}} < \frac{\mathbf{d}\boldsymbol{\theta}}{\mathbf{d}\boldsymbol{v}_{UU}}\boldsymbol{v}_{CR}\boldsymbol{\lambda}\boldsymbol{\mu}_0$*; (d) The risk of the entire chain is reduced if* $\boldsymbol{\xi}(\boldsymbol{A}') > \frac{\Omega \frac{d\xi(A')}{dA'}\omega(v_{UU})}{\mathbf{2}}$.

Lemma 5.6 presents the effects of the standardization of unused products as components for other production processes. Similar to the case of other measures, we identify the conditions under which this measure can improve supply chain profitability, value of quick response and reduce risk.

(2) Industrial Measures

The key to mass customization is effectively postponing the tasks of differentiating a product for a specific customer until the latest possible point. Therefore, the MC system is known to be made up of two different processing phases. It includes the initial phase for the manufacturer to produce the basic items (the standardized ones), which is for taking the advantage of economies of scale and achieving a low unit production cost, and the final phase for conducting the customize-to-order actions after receiving the customer's request (Jiang et al., 2006). In the pre-determination of the basic stock, the major responsibility of MC provider is to choose the number of initial product variants, product family and detailed product specifications, and the complex MC system is based on the balance between modularity and standardization. As a consequence, the salvage value of those un-customized products can be improved by following the below ways.

a) Reducing initial product variants: As is proved by Jiang et al., (2006), a superior MC program is always related to a lower level of initial product variants[45]. For example, the MC providers named Toyota and Volkswagen offer very limited choices on component modules to their customer, but instead, provide an increased variety of final products, which is also efficient in to satisfying the MC consumers. For the MC companies, such level of product range can contribute to high efficiency and economic returns in the prior mass production stage for the MC program. In the meantime, a limited range of component modules is also beneficial in increasing the final salvage value of these leftover products since the modularity can directly determine the degree to which the standard items can be separated or recombined into different components that can be further utilized for creating another new product. The best MC example to illustrate the excellent utilization of modularity is Lego's toys whose various pieces or components can be easily combined together into kinds of shapes in the light of different customized preferences (Selladurai, 2004).

b) Process or component standardization: For the standardization process, it is well known for its benefits of economy of scale (Selladurai, 2004; Rungtusanatham and Salvador, 2008). While in fact, pursuing a reasonable degree of component standardization across different product families in the initial design stage of those un-customized items can also enhance the salvage value of the leftover inventories for the MC channel. According to the Boeing Company, the parts or components of a finished plane can be classified into three categories: standardized, similar and special ones (Gu et al., 2002). Among these three categories, those standardized parts or components can be directly re-used for the next designing and manufacturing process cycle. Then for those similar modules, modification is needed before re-using them. While for those special ones, they

[45] The variants or the variety of MC products can be measured by the number of different MC items that scheme can produce.

should be further designed before reuse, which reflects the highest degree of difficulties for other operations. Although other MC products like the shoes in NIKEiD and Shoe of Prey may not be as complex as a plane, they are also made up of various parts (e.g. the base, vamp, tongue, midsole as well as outsole). Consequently, standardization can benefit every MC firm if they want to improve the salvage value of unsold inventories, which affect the “reusability” of the components in the reverse direction.

5.6 Summary

Given the popularity of consumer returns policies (see the case studies in Chapter 3) and the existence of additional customization process in MC schemes, the leftover products in the fashion MC supply chain have been divided into two subgroups in this chapter, referring to both the un-customized leftovers (i.e., those unsold products which has not been customized yet) as well as the consumer returned items (i.e., already customized ones).

Then under the consideration of two different salvage values of the unsold inventories and consumer returned items, we find that: (i) For the fashion MC supply chain, the evaluated value of quick response can have substantial changes when the consumer returns rate or the salvage values of the consumer returned items and the unused inventories change; (iv) A hybrid coordination mechanism, which combines a buyback contract and a two-part tariff contract, can help achieve win-win coordination with a higher level of flexibility, while the two-part tariff contract only presents limited flexibility; (v) The risk level of the centralized supply chain system has a negative relationship with the consumer returns rate as well as the salvage value of unused inventories, but it has a positive relationship with the salvage value of consumer returned items; (vi) To help improve the performance of the whole fashion MC supply chain, the supply chain members can choose the technology investment measure (e.g., through the Computer-Aided-Design program), the product design improvement measure (e.g., by adopting new materials), or the standardization of component measure (e.g., via improving component standardization). All of these insights provide a helpful guideline for MC retailers to effectively handle the consumer returned items induced by the popular consumer returns policies in MC (as is shown in Chapter 3), and the unsold inventories management problem.

6. Insights, Conclusion and Future Research

This thesis focused on examining supply contracting and channel coordination in fashion mass customization supply chains with consumer returns. A detailed literature review on related papers was firstly conducted in Chapter 2, and the literature considering the application of supply chain contracts in the supply chains with the consideration of consumer returns was deeply investigated, from both of the supply chain structure side and the channel leadership perspective. Afterwards, in-depth case studies on two fashion brands which has launched the MC program and provided consumer returns policies were conducted to present the current situation of MC practices in the fashion industry and empirically demonstrate the significance and motivation of later analytical studies. Then based on the research gap identified from the detailed literature review and the conclusions derived from the case studies, two analytical models were correspondingly established to explore the influence of the quick response policy (in Chapter 4) as well as the different salvage values of consumer returns and unsold inventories (in Chapter 5) on the fashion mass customization supply chains with consumer returns. Coordination contracting mechanisms to enhance the performance of the decentralized supply chain were also examined in both models and various industrial measures to improve the performance of the mass customization program were proposed.

6.1 Important Insights and Conclusion

In this thesis, a number of important insights were derived from the above analyses and some interesting ones were highlighted as follows.

1) **Insights from systematic literature review:** (i) According to the literature review conducted in Chapter 2, it can be seen that the salvage values of consumer returned products and their influence on the optimal ordering quantities as well as supply chain coordination mechanisms are under-explored in supply chain management; (ii) The effects brought by information updating,

together with the existence of consumer returns as well as unsold items on the supply contracting issue, are neglected by the literature on supply contracting in the fashion supply chains; (iii) The manufacturer-led case has already been widely discussed in the existing literature on supply contracting with consumer returns whereas the remaining channel leadership scenarios, such as the retailer-led one, are still under-explored; (iv) Single supply chain contracts like the buyback and returns contract, the revenue sharing contract, the wholesale pricing contract and the two-part tariff contract are also very common in coordination mechanisms design but it is not the case for other supply chain contracts like the hybrid contracts; (v) Although there are various papers analyzing the supply chain management issue on an MC program, none of them has examined the role played by the salvage values of the unsold products and consumer returned items.

2) **Insights from case studies:** (i) Some MC brands, like Nike, and Shoes of Prey, prefer to offer an unconditionally consumer returns policy for their consumers to return unsatisfactory products; (ii) In MC practices, it is common to outsource the production and manufacturing activities to external third parties; (iii) The supply chains of MC brands sometimes may not be responsive and flexible enough to handle the customization requirements received from their consumers. Even for a giant MC brand like Nike, it takes 3-5 weeks to finish the MC process. Therefore, information updating is of great importance in guaranteeing the success of MC; (iv) There is little chance to find another consumer who has the interest in the same products and thus the MC brands probably have to bear the loss of consumer returned items if they fail to find another alternative way to utilize these returned items; (v) Devoting more time and effort into managing leftover inventories, including both the unsold leftovers and consumer returned items, is beneficial to those MC companies.

3) **Insights from the analytical models:** (i) The optimal ordering quantity from the aspect of the fashion retailer is always different from the optimal one for the supply chain; (ii) The quick response policy in the decentralized fashion

supply chain with the MC program has the chance to bring some loss to either one of the players, or even both, and thus some coordination strategies should be developed in order to motivate the members to collaborate; (iii) The fashion MC supply chain will encounter substantial changes in the evaluated value of quick response under different consumer returns percentage conditions or different salvage values of the consumer returned items and the unused inventories; (iv) The two-part tariff contract has limited flexibility in achieving win-win coordination for the fashion MC supply chain but a hybrid coordination mechanism which combines a buyback contract and a two-part tariff contract presents a higher level of flexibility; (v) The centralized supply chain system's risk level has negative relationships with the consumer returns rate and the salvage value of unused leftovers but it has a positive relationship with the salvage value of consumer returned items; (vi) The technology investment measure (e.g., through the Computer-Aided-Design program or the collaborative quality control approach), the product design improvement measure (e.g., by changing the reconfiguration flexibility or adopting new materials), and the standardization of component measure (e.g., via reducing initial product variants or improving process or component standardization) all can help improve the MC supply chain's performance.

6.2 Future Research Directions

Based on the findings indicated above, this thesis can also be further explored in the following aspects:

First, it can be further explored to see if there are any other contracts that can also lead to a win-win situation or both the coordination and all-win outcomes for the fashion MC supply chain proposed in this thesis. Moreover, the fashion retailer and the manufacturer may be risk averse rather than risk-neutral as assumed in this thesis. As a result, the contracts proposed in this thesis may become inefficient since the players may focus more on various uncertainties induced by the mass customization program (e.g., the consumer returns) or the quick response policy. Thus, the performance of these contracts should be further discussed and some other contracts such as the risk-sharing contract can be designed to see whether it can successfully coordinate the new MC supply chain.

Second, analytical analyses on an optimal two-stage two-ordering policy for our explored MC program can be conducted. That is, before the start of the selling season, the fashion retailer can place orders for the un-customized products from the manufacturer at either Time 0 or Time 1, or even both, based on the forecast of market demand and other relevant parameters. Therefore, a two-stage dynamic optimization problem for this program can be formulated to find an optimal policy.

Third, given the popularity of consumer returns in MC, it is interesting to further study the induced reverse logistics area (e.g., the M+RM link or the R+RM link), which is a very timely and critical field nowadays owing to the growing awareness of environmental sustainability. In addition, the coordination issue can also be deeply examined considering a more general and complex fashion MC supply chain.

Appendix A- Supplementary Tables and Figures for Chapter 2

Table A1. Definitions of different "situations"

	Link	Contract
Situation A	Single	Single
Situation B	Single	Multiple
Situation C	Multiple	
Situation D	Single and Multiple together	

Table A2. Articles under Situation A

SC contracts	Corresponding reference
Buyback and returns contract	Arcelus et al. (2011), Bose and Anand (2007), Chen (2011), Chen and Bell (2011), Gu and Tagaras (2014), He et al. (2006), Hou et al. (2010), Huang et al. (2015), Jeong (2012), Lee and Rhee (2007), Li et al., (2012b), Liu et al., (2014), Matsui (2010), Ohmura and Matsuo (2016), Wu (2013), Xu et al. (2015), Yao et al. (2008), Zhang et al., (2015);
Revenue sharing contract	Mafakheri and Nasiri (2013), Ran et al. (2016), Weraikat et al. (2016), Wu et al. (2015), Zeng (2013), Zou and Ye (2015), Giri et al., (2017), Xie et al., (2017);
Wholesale pricing contract	Atasu et al. (2013), Hong et al. (2008), Hong and Yeh (2012), Li and Li (2016), Li et al. (2012a), Ye et al. (2016);
Two-part tariff contract	Dobos et al. (2013), Gao et al. (2016), Hong et al. (2015), Kaya (2010);
Quantity discount contract	Huang et al. (2011), Jena and Sarmah (2016);
Risk sharing contract	He (2015), He and Zhang (2010);
Consignment contract	Hu et al. (2014);
Rebate contract	Ferguson et al. (2006);
Papers mentioning more than one contracts separately	Chen and Chang (2014), De Giovanni (2014), Huang et al. (2014), Ruiz-Benitez and Muriel (2014), Song et al. (2008), Su (2009), Xiao et al. (2010), Yoo et al. (2015), Zhang et al. (2014a), Zhao and Zhu (2015), Hu et al., (2016);

Appendix B- Mathematical Proofs for Chapter 4

(B1) Derivations for Section 4.2

According to our discussion in Section 4.2, we have the expected profit of the whole supply chain at Time 0 as:

$E[\pi_{SC,0}^{C}\ (q)] = (\tau\ +\ k - \alpha - v)\mu_0 - (m - v)q - (\tau\ +$

$k - \alpha - v)\int_q^{\infty}(x - q)f(x)dx$. (B.1)

Substituting $q_0 = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(y)$ into (B.1), we have:

$E[\pi_{SC,0}^{C}\ (q)] = (\tau\ +\ k - \alpha - v)\mu_0 - (m - v)\ q - (\tau\ +$

$k - \alpha - v)\sqrt{d_0\ +\ \delta}Z(\frac{q - \mu_0}{\sqrt{d_0\ +\ \delta}})$. (B.2)

As a result, the optimal ordering quantity from the perspective of the entire supply chain can be found by solving the following optimization problem:

$q_0^{C*} = arg\{maxE[\pi_{SC,0}^{C}\ (q)]\}$

$\Leftrightarrow\ arg\{max\ (\tau\ +\ k - \alpha - v)\mu_0 - (m - v)\ q - (\tau\ +$

$k - \alpha - v)\sqrt{d_0\ +\ \delta}Z(\frac{q - \mu_0}{\sqrt{d_0 + \delta}})\}$.

Note that $\frac{dZ(a(q))}{dq} = (F(a(q)) - 1)\frac{da(q)}{dq}$. Thus, differentiating (B.2) once and twice with respect to q yields:

$$\frac{dE[\pi_{SC,0}^{C}\ (q)]}{dq} = (\tau\ +\ k - \alpha - m) - (\tau\ +\ k - \alpha - v)\ F(\frac{q - \mu_0}{\sqrt{d_0 + \delta}}),$$

$$\frac{d^2E[\pi_{SC,0}^{C}\ (q)]}{dq^2} = -\frac{(\tau + k - \alpha - v)}{\sqrt{d_0\ + \delta}}f(\frac{q - \mu_0}{\sqrt{d_0\ + \delta}}) < 0.$$

It is obvious that $E[\pi_{SC,0}^{C}\ (q)]$ is a strictly concave function and the optimal ordering quantity q_0^{C*} is:

$$q_0^{C*} = arg\{\frac{dE\left[\pi_{SC,0}^{C}\ (q)\right]}{dq} = 0\} = \mu_0 + \sqrt{d_0\ +\ \delta}F^{-1}(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v})\ . \quad \text{(B.3)}$$

Substitute (B.3) into (B.2) gives the optimal expected profit function of the whole supply chain at Time 0:

$E[\pi_{SC,0}^{C*}\ (q_0^{C*})] = (\tau\ +\ k - \alpha - v)\mu_0 - (m - v)q_0^{C*} - (\tau\ +$

$k - \alpha - v)\sqrt{d_0 + \delta}Z(F^{-1}(s_0^{C*}))$, where $s_0^{C*} = \frac{\tau+k-\alpha-m}{\tau+k-\alpha-v} = \frac{p-(p-v)\lambda-\alpha-m}{p-(p-v)\lambda-\alpha-v}$.

Similar to the above analysis, at Time 1, it is easy to find that:

$$E[\pi_{sc,1}^{C}(q)] = (\tau + k - \alpha - v)\mu_1 - (m - v)\, q - (\tau + k - \alpha - v)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}}). \quad \text{(B.4)}$$

We can derive the optimal ordering quantity by:

$$q_1^{C*} = arg\{maxE[\pi_{sc,1}^{C}(q)]\}$$

$$\Leftrightarrow arg\{max\,(\tau + k - \alpha - v)\mu_1 - (m - v)\, q - (\tau + k - \alpha - v)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}})\}.$$

It is straightforward to find that $\frac{d^2E[\pi_{sc,1}^{C}(q)]}{dq^2} < 0$ and therefore, it is also a strictly concave function and the optimal ordering quantity at Time 1 can be found by:

$$q_1^{C*} = arg\{\frac{dE[\pi_{sc,1}^{C}(q)]}{dq} = 0\} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau+k-\alpha-m}{\tau+k-\alpha-v}). \quad \text{(B.5)}$$

Substitute (B.5) into (B.4) yields the optimal expected profit function of the whole supply chain at Time 1 as follows:

$$E[\pi_{sc,1}^{C*}(q_1^{C*})] = (\tau + k - \alpha - v)\mu_1 - (m - v)q_1^{C*} - (\tau + k - \alpha - v)\sqrt{d_1 + \delta}Z(F^{-1}(s_1^{C*})),$$

where $s_1^{C*} = \frac{\tau+k-\alpha-m}{\tau+k-\alpha-v} = \frac{p-(p-v)\lambda-\alpha-m}{p-(p-v)\lambda-\alpha-v} = s_0^{C*}$.

(Q.E.D.)

(B2) Derivations for Section 4.3

Notice from Section 4.2 that the expected profit of the fashion retailer at Time 0 is:

$$E[\pi_{r,0}^{R}(q)] = (\tau - c_0)q - (\tau - v)\int_{-\infty}^{q}(q - x)f(x)dx. \quad \text{(B.6)}$$

By substituting $q_0 = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(y)$ into (B.6), we have:

$$E[\pi_{r,0}^{R}(q)] = (\tau - v)\mu_0 - (c_0 - v)\, q - (\tau - v)\sqrt{d_0 + \delta}Z(\frac{q - \mu_0}{\sqrt{d_0 + \delta}}). \quad \text{(B.7)}$$

With this expression, we can derive the optimal ordering quantity from the perspective of the fashion retailer by solving the following optimization problem:

$q_0^{R*} = arg\{max\ E[\pi_{r,0}^{R}\ (q)]\}$

$\Leftrightarrow arg\{max(\tau - v)\mu_0 - (c_0 - v)\ q - (\tau - v)\sqrt{d_0 + \delta}Z(\frac{q - \mu_0}{\sqrt{d_0 + \delta}})\}.$

Considering that $\frac{dZ(a(q))}{dq} = (F(a(q)) - 1)\frac{da(q)}{dq}$, we take the first and second order derivations of (B.7) with respect to q:

$\frac{dE[\pi_{r,0}^{R}\ (q)]}{dq} = (\tau - c_0) - (\tau - v)\ F(\frac{q - \mu_0}{\sqrt{d_0 + \delta}}),$

$\frac{d^2E[\pi_{r,0}^{R}\ (q)]}{dq^2} = - \frac{(\tau - v)}{\sqrt{d_0 + \delta}}f(\frac{q - \mu 0}{\sqrt{d0 + \delta}}) < 0\ .$

Based on above, it is obvious that $E[\pi_{r,0}^{R}\ (q)]$ is a strictly concave function and the optimal ordering quantity q_0^{R*} is:

$q_0^{R*} = arg\{\frac{dE[\pi_{r,0}^{R}\ (q)]}{dq} = 0\} = \mu_0 + \sqrt{d_0 + \delta}F^{-1}(\frac{\tau - c_0}{\tau - v}).$ (B.8)

Substitute (B.8) into (B.7) yields the optimal expected profit function of the fashion retailer at Time 0 as follows:

$E[\pi_{r,0}^{R*}\ (q_0^{R*})] = (\tau - v)\mu_0 - (c_0 - v)\ q_0^{R*} - (\tau - v)\sqrt{d_0 + \delta}Z(F^{-1}(s_0^{R*})),$

where $s_0^{R*} = \frac{\tau - c_0}{\tau - v} = \frac{p-(p-v)\lambda-k-c_0}{p-(p-v)\lambda-k-v}.$

The way to derive the derive the expected profit function of the fashion retailer at Time 1 is similar to Time 0, and it can be expressed as:

$E[\pi_{r,1}^{R}\ (q)] = (\tau - v)\mu_1 - (c_1 - v)\ q - (\tau - v)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}}),$ (B.9)

The optimal ordering quantity can be found by solving:

$q_1^{R*} = arg\{maxE[\pi_{r,1}^{R}\ (q)]\}$

$\Leftrightarrow arg\{max(\tau - v)\mu_1 - (c_1 - v)\ q - (\tau - v)\sqrt{d_1 + \delta}Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}})\}.$

Since $\frac{d^2E[\pi_{r,1}^{R}\ (q)]}{dq^2} < 0$, it can be concluded that $E[\pi_{r,1}^{R}\ (q)]$ is also a strictly concave function. Therefore, the optimal ordering quantity at Time 1 is given by:

$q_1^{R*} = arg\{\frac{dE\left[\pi_{r,1}^{R}\ (q)\right]}{dq} = 0\} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau - c_1}{\tau - v}).$ (B.10)

Substitute (B.10) into (B.9) leads to the optimal expected profit function of the retailer at Time 1:

$$E[\pi_{r,1}^{R*}(q_1^{R*})] = (\tau - v)\mu_1 - (c_1 - v)\, q_1^{R*} - (\tau - v)\sqrt{d_1 + \delta} Z(F^{-1}(s_1^{R*})),$$

where $s_1^{R*} = \frac{\tau - c_1}{\tau - v} = \frac{p-(p-v)\lambda - k - c_1}{p-(p-v)\lambda - k - v}$.

(Q.E.D.)

(B3) Proof of Lemma 4.1.

From the retailer's side:

Referring to the results we have presented before, we have:

$$E[\pi_{r,0}^{R*}(q_0^{R*})] = (\tau - v)\mu_0 - (c_0 - v)q_0^{R*} - (\tau - v)\sqrt{d_0 + \delta} Z(F^{-1}(s_0^{R*})). \quad \text{(B.11)}$$

By substituting $q_0^{R*} = \mu_0 + \sqrt{d_0 + \delta} F^{-1}(\frac{\tau - c_0}{\tau - v})$ into (B.11), we derive another expression of $E[\pi_{r,0}^{R*}(q_0^{R*})]$ as:

$$E[\pi_{r,0}^{R*}(q_0^{R*})] = (\tau - c_0)\mu_0 - (\tau - v)\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})).$$

Similarly, we also have:

$$E[\pi_{r,1}^{R*}(q_1^{R*})] = (\tau - c_1)\mu_1 - (\tau - v)\sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*})).$$

In order to find the impact of the quick response policy on the fashion retailer when the MC program is conducted, we define $EPQR_r^R = E[\pi_{r,1}^{R*}(q^{R*})] - E[\pi_{r,0}^{R*}(q_0^{R*})]$, which denotes the benefit gained by the retailer under the quick response policy. However, according to the Bayesian model, μ_1 is a random variable (i.e., unknown) at Time 0. In order to give a deterministic measure when comparing the performance of the decentralized mode at these two time stages, we take unconditional expectation on $E(\pi_{r,1}^{R*}(q^{R*})|\mu_1)$ with respect to μ_1, and thus:

$$EPQR_r^R =$$
$$(\tau - v)[\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*}))] - (c_1 - c_0)\mu_0.$$

Moreover, based on our previous discussion, we have $s_0^{R*} > s_1^{R*}$, $c_1 > c_0$, $\tau > v$, as well as $\sqrt{d_0 + \delta} > \sqrt{d_1 + \delta}$, therefore:

When $s_0^{R*} > s_1^{R*} > 0.5$, which implies both $F^{-1}(s_0^{R*}) > F^{-1}(s_1^{R*}) > 0$ and

$f\left(F^{-1}(s_1^{R*})\right) > f(F^{-1}(s_0^{R*})) > 0$, and it is easy to find that:

$EPQR_r^R > 0$, if and only if c_1 satisfies $(\tau - v)\sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*})) + c_1\mu_0 > (\tau - v)\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) + c_0\mu_0$.

If $s_1^{R*} < s_0^{R*} < 0.5$, it is straight that $F^{-1}(s_1^{R*}) < F^{-1}(s_0^{R*}) < 0$, $f(F^{-1}(s_0^{R*})) > f\left(F^{-1}(s_1^{R*})\right) > 0$, and $\sqrt{d_0 + \delta} f\left(F^{-1}(s_0^{R*})\right) > \sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*}))$, therefore:

$EPQR_r^R > 0$ if and only if c_1 satisfies $(\tau - v)\sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*})) + c_1\mu_0 > (\tau - v)\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) + c_0\mu_0$.

From the manufacturer's side:

First, we also define $EPQR_{\mathrm{m}}^R = E\left(\pi_{m,1}^{R*}(q^{R*})\middle|\mu_1\right) - E[\pi_{\mathrm{m},0}^{R*}(q_0^{R*})]$. Then, we take expectation with respect to μ_1 and yields:

$EPQR_{\mathrm{m}}^R = (c_1 - c_0)\mu_0 +$

$(k - \alpha)[\sqrt{d_1 + \delta} F^{-1}(s_1^{R*})(1 - s_1^{R*}) - \sqrt{d_0 + \delta} F^{-1}(s_0^{R*})(1 - s_0^{R*})] +$

$(k - \alpha)(\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*}))) +$

$[(c_1 - m)\sqrt{d_1 + \delta} F^{-1}(s_1^{R*}) - (c_0 - m)\sqrt{d_0 + \delta} F^{-1}(s_0^{R*})]$.

It can be found that no matter whether $s_0^{R*} > s_1^{R*} > 0.5$ or $s_1^{R*} < s_0^{R*} < 0.5$, $EPQR_{\mathrm{m}}^R > 0$ if and only if c_1 satisfies:

$[(k - \alpha)(1 - s_1^{R*}) + (c_1 - m)]\sqrt{d_1 + \delta} F^{-1}(s_1^{R*}) - (k - \alpha)\sqrt{d_1 + \delta} f\left(F^{-1}(s_1^{R*})\right) +$

$c_1\mu_0 > [(k - \alpha)(1 - s_0^{R*}) +$

$(c_0 - m)]\sqrt{d_0 + \delta} F^{-1}(s_0^{R*}) - (k - \alpha)\sqrt{d_0 + \delta} f\left(F^{-1}(s_0^{R*})\right) + c_0\mu_0$.

Since $EPQR_{\mathrm{SC}}^R = EPQR_{\mathrm{r}}^R + EPQR_{\mathrm{m}}^R$, we have:

$EPQR_{\mathrm{SC}}^R =$

$(p - \alpha - v - (p - v)\lambda)[\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta} f(F^{-1}(s_1^{R*}))] +$

$[(k - \alpha)(1 - s_1^{R*}) + (c_1 - m)]\sqrt{d_1 + \delta} F^{-1}(s_1^{R*}) - [(k - \alpha)(1 - s_0^{R*}) +$

$(c_0 - m)]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*})$.

(Q.E.D.)

(B4) Proof of Lemma 4.2 (b)

Under the two-part tariff contract, we have $q^{T*} = \mu_1 + \sqrt{d_1 + \delta}F^{-1}(\frac{\tau - m}{\tau - v})$, $s^{T*} = \frac{\tau - m}{\tau - v}$ (when $\lambda < 1 - \frac{k}{p - c_1}$). Thus, it is straightforward to find that the expected profits of these two members under the revised optimal ordering quantity in the presence of a two-part tariff contract are:

$E[\pi_{r,1}^{T}(q^{T*})] = (\tau - m)\mu_1 - (\tau - v)\sqrt{d_1 + \delta}f(F^{-1}(s^{T*})) - A$,

$E[\pi_{m,1}^{T}(q^{T*})] = (k - \alpha)\mu_1 - (k - \alpha)\sqrt{d_1 + \delta}f(F^{-1}(s^{T*})) + A$.

According to Section 4.5.1, we have$EPQR_r^T = E[\pi_{r,1}^{T}(q^{T*})] - E[\pi_{r,0}^{R*}(q_0^{R*})]$, and

$EPQR_m^T = E[\pi_{m,1}^{T}(q^{T*})] - E[\pi_{m,0}^{R*}(q_0^{R*})]$.

By taking expectation with respect to μ_1, we find that:

$EPQR_r^T =$

$(\tau - v)[\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta}f(F^{-1}(s^{T*}))] - (m - c_0)\mu_0 - A$,

$EPQR_m^T = (m - c_0)\mu_0 +$

$[\frac{(k - \alpha)(m - v)}{p - (p - v)\lambda - k - v}]\sqrt{d_1 + \delta}F^{-1}(s^{T*}) - [\frac{(k - \alpha)(c_0 - v)}{p - (p - v)\lambda - k - v} - (m - c_0)]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) +$

$(k - \alpha)(\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta}f(F^{-1}(s^{T*}))) + A$.

According to the definition, the two-part tariff contract can lead to a win-win result for adopting quick response policy under the MC program by setting a value of A with which (i) $EPQR_r^T > 0$ and (ii) $EPQR_m^T > 0$. As a result, the range of A can be derived by setting $\underline{A} < A < \overline{A}$, where$\underline{A} = \arg\{EPQR_m^T(A)\} = 0$, $\overline{A} = \arg\{EPQR_r^T(A)\} = 0$, $\underline{A} < \overline{A}$. Thus, it is straight to observe that:

$\underline{A} = (c_0 - m)\mu_0 - [\frac{(k - \alpha)(m - v)}{p - (p - v)\lambda - k - v}]\sqrt{d_1 + \delta}F^{-1}(s^{T*}) +$

$[\frac{(k - \alpha)(c_0 - v)}{p - (p - v)\lambda - k - v} - (m - c_0)]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) - (k - \alpha)(\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta}f(F^{-1}(s^{T*})))$

$, \overline{A} = (p - k - (p - v)\lambda - v)[\sqrt{d_0 + \delta} f(F^{-1}(s_0^{R*})) - \sqrt{d_1 + \delta} f(F^{-1}(s^{T*}))] - (m - c_0)\mu_0,$

where $s^{T*} = \frac{\tau - m}{\tau - v}$.

(Q.E.D.)

(B5) Derivations for Section 4.5.2

With the assumptions and formulations given in Section 4.5.2, we have:

$E[\pi_{r,1}^H(q)] = (\tau^H - m)q - (\tau^H - b)\int_{-\infty}^{q}(q - x)f(x)dx - A$, where $\tau^H = p - k - (p - b)\lambda$,

$\Leftrightarrow E[\pi_{r,1}^H(q)] = (\tau^H - b)\mu_1 - (m - b)\, q - (\tau^H - b)\sqrt{d_1 + \delta} Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}}) - A$.

(B.12)

$E[\pi_{m,1}^H(q)] = (k - \alpha - (b - v)\lambda)q - [k - \alpha + (b - v)(1 - \lambda)]\int_{-\infty}^{q}(q - x)f(x)dx + A.$

$\Leftrightarrow E[\pi_{m,1}^H(q)] = (k - \alpha + (b - v)(1 - \lambda))\mu_1 - (b - v)\, q - (k - \alpha + (b - v)(1 - \lambda))\sqrt{d_1 + \delta} Z(\frac{q - \mu_1}{\sqrt{d_1 + \delta}}) + A.$ (B.13)

Differentiating (B.12) once and twice with respect to q yields:

$\frac{dE[\pi_{r,1}^H(q)]}{dq} = (\tau^H - m) - (\tau^H - b)F(\frac{q - \mu_1}{\sqrt{d_1 + \delta}})$,

$\frac{d^2E[\pi_{r,1}^H(q)]}{dq^2} = -\frac{(\tau^H - b)}{\sqrt{d1 + \delta}} f(\frac{q - \mu_1}{\sqrt{d_1 + \delta}}) < 0,$

It can be observed that when $\lambda < 1 - \frac{k}{p - c_1}$, $E[\pi_{m,1}^H(q)]$ is a strictly concave function. Therefore, the optimal ordering quantity under the hybrid contract is:

$q^{H*} = arg\{\frac{dE[\pi_{r,1}^H(q)]}{dq} = 0\} = \mu_1 + \sqrt{d_1 + \delta} F^{-1}(\frac{\tau^H - m}{\tau^H - v}),$ (B.14)

where $s^{H*} = \frac{\tau^H - m}{\tau^H - b} = \frac{p - (p - b)\lambda - k - m}{p - (p - b)\lambda - k - b}$.

(Q.E.D.)

(B6) Proof of Lemma 4.3

To achieve supply chain coordination, we need to find a value of b that can lead to: $q^{H*} = q_1^{C*}$. As a result, it can be found that $b =$

$\frac{m[k - v(1-\lambda)-\alpha]+v[p(1-\lambda)-k]}{(p-m)(1-\lambda)-\alpha}$.

Substitute (B.14) into (B.12) and (B.13) leads to the updated expected profit function of the retailer and the manufacturer at Time 1 as follows:

$$E\left[\pi_{r,1}^{H}(q^{H*})\right] = (\tau^{H} - m)\mu_1 - (\tau^{H} - b)\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})) - A. \quad \text{(B.15)}$$

$$E\left[\pi_{m,1}^{H}(q^{H*})\right] = (k - \alpha + (b - v)(1-\lambda))\mu_1 - (b - v)\,q^{H*} - (k - \alpha +$$

$$(b - v)(1-\lambda))\sqrt{d_1 + \delta}Z(F^{-1}(s^{H*})) + A, \text{ where } s^{H*} = \frac{\tau^{H} - m}{\tau^{H} - b} = \frac{p-(p-b)\lambda-k-m}{p-(p-b)\lambda-k-b}.$$

Define $EPQR_r^H = E\left[\pi_{r,1}^{H}(q^{H*})\right] - E[\pi_{r,0}^{R*}(q_0^{R*})]$, and $EPQR_m^H = E\left[\pi_{m,1}^{H}(q^{H*})\right] - E[\pi_{m,0}^{R*}(q_0^{R*})]$.

After taking expectation with respect to μ_1, we have:

$$EPQR_r^H = (p - k - (p - v)\lambda - v)\sqrt{d_0 + \delta}f\left(F^{-1}(s_0^{R*})\right) - (p - k - (p - b)\lambda - b)\sqrt{d_1 + \delta}f\left(F^{-1}(s^{H*})\right) - (m - c_0 - (b - v)\lambda)\mu_0 - A.$$

$$EPQR_m^H = (m - c_0 - (b - v)\lambda)\mu_0 + \left(\frac{(k - \alpha + (b - v)(1-\lambda))(m-b)}{p-(p-b)\lambda-k-b} - (b - v)\right)F^{-1}(s^{H*}) - \left[\frac{(k - \alpha)(c_0-v)}{p-(p-v)\lambda-k-v} - (m - c_0)\right]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) + (k-\alpha)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - (k - \alpha + (b - v)(1-\lambda))\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})) + A.$$

According to the definition, the hybrid contract can lead to a win-win result for adopting quick response policy under the MC program by setting a value of A with which (i) $EPQR_r^H > 0$ and (ii) $EPQR_m^H > 0$. That is, the given value of A should be in the range $\underline{A} < A < \overline{A}$, where:

$$\underline{A} = \left[\frac{(k - \alpha)(c_0 - v)}{p - (p - v)\lambda - k - v} - (m - c_0)\right]\sqrt{d_0 + \delta}F^{-1}(s_0^{R*}) + (k - \alpha + (b - v)(1-\lambda))\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})) - (k - \alpha)\sqrt{d_0 + \delta}f(F^{-1}(s_0^{R*})) - (m - c_0 - (b - v)\lambda)\mu_0 - \left[\frac{(k - \alpha + (b - v)(1-\lambda))(m-b)}{p-(p-b)\lambda-k-b} - (b - v)\right]\sqrt{d_1 + \delta}F^{-1}(s^{H*}),$$

$$\overline{A} = -(m - c_0 - (b - v)\lambda)\mu_0 + (p - k - (p - v)\lambda - v)\sqrt{d_0 + \delta}f(F^{-1}(s^{H*})) - (p - k - (p - b)\lambda - b)\sqrt{d_1 + \delta}f(F^{-1}(s^{H*})).$$

Appendix C For Chapter 5

Appendix C1-All Mathematical Proofs.

C1. 1. Proof of Lemma 5.1.

It is straightforward to observe that $EPQR_m^R > 0$; while $EPQR_r^R > 0$ if and only if $\frac{p-2c+v_{UU}}{p-v_{CR}} < \lambda < \frac{p-c}{p-v_{CR}}$. Therefore, the occurrence of win-win situation is bounded by the condition of $\frac{p-2c+v_{UU}}{p-v_{CR}} < \lambda < \frac{p-c}{p-v_{CR}}$.

By taking the first order derivative, it can be concluded that the difference between two boundaries of λ is a decreasing function of v_{UU} but an increasing function of v_{CR}.

(Q.E.D.)

C1. 2. Proof of Corollary 5.1.

Based on previous discussions, we have:

$EPQR_r^R = E\left(\pi_{r,1}^{R*}(q_1^{R*})\middle|\mu_1\right) - E\left(\pi_{r,0}^{R*}(q_0^{R*})\right) = (\sqrt{d_0+\delta} - \sqrt{d_1+\delta})\Omega f((F^{-1}(s^{R*}));$

$EPQR_m^R = E\left(\pi_{m,1}^{R*}(q_1^{R*})\middle|\mu_1\right) - E\left(\pi_{m,0}^{R*}(q_0^{R*})\right) = -(\sqrt{d_0+\delta} - \sqrt{d_1+\delta})(c-m)F^{-1}(s^{R*})$. Then by taking the first order derivation, it can be derived that:

(a) $\frac{dEPQR_m^R}{dv_{CR}} = -\left(\sqrt{d_0+\delta} - \sqrt{d_1+\delta}\right)(c-m)\frac{dF^{-1}(s^{B*})}{ds^{B*}}\frac{\lambda(c-v_{UU})}{\Omega^2} < 0.$

(b) $\frac{dEPQR_{\mathrm{r}}^R}{dv_{CR}} > 0$ if and only if $\lambda > \Omega A\tau(v_{CR})$; $\frac{dEPQR_{\mathrm{r}}^R}{dv_{CR}} < 0$ if and only if $\lambda < \Omega A\tau(v_{CR})$;

Besides, when $s^{B*} < 0.5$, $A(v_{CR}) < 0, \lambda - \Omega A\tau(v_{CR}) > 0$, $\frac{dEPQR_{\mathrm{r}}^R}{dv_{CR}} > 0$, $s^{B*} < 0.5 \Leftrightarrow \frac{c-(1-\lambda)p}{\lambda} < v_{CR} < \frac{2c-(1-\lambda)p-v_{UU}}{\lambda}$.

(c) Similarly, we have: $\frac{dEPQR_{SC}^R}{dv_{CR}} > 0$ if and only if $\lambda - \Omega A\tau(v_{CR}) > \frac{(c-m)\tau(v_{CR})}{f(A)}$; $\frac{dEPQR_{SC}^R}{dv_{CR}} < 0$ if and only if $\lambda - \Omega A\tau(v_{CR}) < \frac{(c-m)\tau(v_{CR})}{f(A)}$.

(Q.E.D.)

C1. 3. Proof of Corollary 5.2. Similar to the proof of Corollary 5.1.

C1. 4. Proof of Lemma 5.2.

The optimal expected profits of the fashion retailer and the upstream manufacturer under a two-part tariff contract is updated as:

$E\left[\pi_{r,1}^{T}(q_1^{T*})\right] = [(1-\lambda)p + v_{CR}\lambda - c']\mu_1 - [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\sqrt{d_1+\delta}f\left(F^{-1}(s^{T*})\right) - A;$

$E[\pi_{m,1}^{T}(q_1^{T*})] = (c'-m)[\mu_1 + \sqrt{d_1+\delta}F^{-1}(s^{T*})] + A \;\; s^{T*} = \frac{(1-\lambda)p+v_{CR}\lambda-c'}{(1-\lambda)p+v_{CR}\lambda-v_{UU}}.$

It is easy to find that if $c' = m$, the coordination of the MC supply chain can be attained. Then by setting A in the range of $(c-m)[\mu_0 + \sqrt{d_0+\delta}F^{-1}(s^{R*})] < A < (c-m)\mu_0 + \Omega[\sqrt{d_0+\delta}f\left(F^{-1}(s^{R*})\right) - \sqrt{d_1+\delta}f(F^{-1}(s^{C*}))]$, the condition of $EPQR_m^T > 0$ and $EPQR_r^T > 0$ can be ensured, which means a win-win outcome for the two members.

(Q.E.D.)

C1. 5. Proof of Proposition 5.1.

The revised expected profits of the manufacturer and the retailer under the hybrid contract are:

$$E\left[\pi_{r,1}^{H}(q)\right] = [(1-\lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\mu_1 - (c-\theta v_{UU})q - [(1-\lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\sqrt{d_1+\delta}Z\left(\frac{q-\mu_1}{\sqrt{d_1+\delta}}\right) - A, \quad \text{(C.1)}$$

$$E\left[\pi_{m,1}^{H}(q)\right] = [(\theta-1)(v_{UU} - v_{CR}\lambda)]\mu_1 + [c - m - (\theta-1)v_{UU}]q - [(\theta-1)(v_{UU} - v_{CR}\lambda)]\sqrt{d_1+\delta}Z\left(\frac{q-\mu_1}{\sqrt{d_1+\delta}}\right) + A. \quad \text{(C.2)}$$

By differentiating (C.1) once and twice with respect to q, we find that $E\left[\pi_{r,1}^{H}(q)\right]$ is concave and hence it can be derived that the optimal ordering quantity under the hybrid contract is:

$$q_1^{H*} = \mu_1 + \sqrt{d_1+\delta}F^{-1}(\frac{(1-\lambda)p+\theta v_{CR}\lambda-c}{(1-\lambda)p+\theta v_{CR}\lambda-\theta v_{UU}}),\ s^{H*} = \frac{(1-\lambda)p+\theta v_{CR}\lambda-c}{(1-\lambda)p+\theta v_{CR}\lambda-\theta v_{UU}}. \quad (C.3)$$

To achieve supply chain coordination, we need to find a value of θ that can make $q_1^{H*}(c,\theta,A) = q_1^{C*}$.

Thus, $\theta = \frac{c[(1-\lambda)p+v_{CR}\lambda- v_{UU}]-(1-\lambda)(m-v_{UU})p}{\lambda m v_{CR}-m v_{UU}+(1-\lambda)p v_{UU}} = 1 + \frac{\Omega(\mathrm{c}-m)}{\lambda m v_{CR}+[(1-\lambda)p-m]v_{UU}}$..

Apart from the above, in order to achieve win-win coordination, we need $EPQR_m^H > 0$ and $EPQR_r^H > 0$.

Then by substituting (C.3) into (C.1) and (C.2) simultaneously, we have

$EPQR_r^H = E\left(\pi_{r,1}^{H*}(q_1^{H*})\middle|\mu_1\right) - E\left(\pi_{r,0}^{R*}(q_0^{R*})\right) = (\theta-1)v_{CR}\lambda\mu_0 - [(1-\lambda)p + \theta v_{CR}\lambda - \theta v_{UU}]\sqrt{d_1+\delta}f\left(F^{-1}\left(s^{H*}\right)\right) + [(1-\lambda)p + v_{CR}\lambda - v_{UU}]\sqrt{d_0+\delta}f\left(F^{-1}(s^{R*})\right) - A;$

$EPQR_m^H = E\left(\pi_{m,1}^{H*}(q_1^{H*})\middle|\mu_1\right) - E\left(\pi_{m,0}^{R*}(q_0^{R*})\right) = A - (\theta-1)v_{CR}\lambda\mu_0 - [(\theta - 1)(v_{UU} - v_{CR}\lambda)]\sqrt{d_1+\delta}f\left(F^{-1}\left(s^{H*}\right)\right) - (c-m)\sqrt{d_0+\delta}F^{-1}(s^{R*}) + \left[c - m - (\theta-1)v_{CR}\lambda - (\theta-1)(v_{UU}-v_{CR}\lambda)s^{H*}\right]\sqrt{d_1+\delta}F^{-1}\left(s^{H*}\right).$

It can be found that: a win-win outcome can be achieved when the parameter A in the range of $\underline{A} < A < \overline{A}$, where:

$\underline{A} = (\theta-1)v_{CR}\lambda\mu_0 + [(\theta-1)(v_{UU}-v_{CR}\lambda)]\sqrt{d_1+\delta}f\left(F^{-1}\left(s^{H*}\right)\right) - \Delta F^{-1}(s)$;

$\overline{A} = (\theta-1)v_{CR}\lambda\mu_0 - \Delta f\left(F^{-1}(s)\right).$

Then we have Proposition 5.1.

(Q.E.D.)

C1. 6. Proof of Lemma 5.3.

Parts a) and c): According to $\mathrm{V}\left(\pi_{i,sc}\left(q_i^{C*}\right)\right) = \Omega^2(d_i+\delta)\xi(F^{-1}\left(s^{C*}\right))$, we have:

$$\frac{d\mathrm{V}\left(\pi_{sc,i}(q_i^{C*})\right)}{d\lambda} = 2(-p + v_{CR})\Omega(d_i + \delta)\xi(A') + \Omega^2(d_i + \delta)\frac{d\xi(A')}{dA'}\omega(\lambda);$$

$$\frac{d\mathrm{V}\left(\pi_{sc,i}(q_i^{C*})\right)}{dv_{UU}} = -2\Omega(d_i + \delta)\xi(A') + \Omega^2(d_i + \delta)\frac{d\xi(A')}{dA'}\omega(v_{UU});$$

thus, it is obvious that:

$$\frac{d\mathrm{V}\left(\pi_{sc,i}(q_i^{C*})\right)}{d\lambda} < 0 \text{ if and only if } \xi(A') < \frac{\Omega\frac{d\xi(A')}{dA'}\omega(\lambda)}{2(p-v_{CR})};$$

$$\boldsymbol{\frac{d\mathrm{V}\left(\pi_{sc,i}(q_i^{C*})\right)}{dv_{UU}} < 0} \text{ if and only if } \boldsymbol{\xi(A') > \frac{\Omega\frac{d\xi(A')}{dA'}\omega(v_{UU})}{2}}.$$

Part b) From the expression, it is straightforward to note that a larger salvage value of consumer returns would lead to a higher variance of supply chain profit. (Q.E.D.)

C1. 7. Proof of Lemma 5.4.

(a) This is based on the first order derivation of the expected profit of the entire chain.

(b) Based on the previous analysis, we have:

$$EPQR_{SC}^R = EPQR_r^R + EPQR_m^R = \left(\sqrt{d_0 + \delta} - \sqrt{d_1 + \delta}\right)\Omega\mathrm{f}\left(F^{-1}(s^{R*})\right) - \left(\sqrt{d_0 + \delta} - \sqrt{d_1 + \delta}\right)(c - m)F^{-1}(s^{R*}).$$

Then by taking the first order derivation, it can be derived that:

$$\frac{dEPQR_{SC}^R}{d\lambda} = \left(\sqrt{d_0 + \delta} - \sqrt{d_1 + \delta}\right)\{(-p + v_{CR})f(A) + \Omega A f(A)\varepsilon(\lambda) + (c - m)\varepsilon(\lambda)\}.$$

Thus, we have: $\frac{dEPQR_{SC}^R}{d\lambda} < 0$ if and only if $\Omega A\phi(A) + (c - m) < \frac{(p-v_{CR})f(A)}{\varepsilon(\lambda)}$.

(c) Differentiating $\underline{A}$ and $\overline{A}$ with λ, we have:

$\frac{d\underline{A}}{d\lambda} > 0$ if and only if $\frac{\mathrm{d}\Delta F^{-1}(s)}{\mathrm{d}\lambda} + k(\lambda)\sqrt{d_1 + \delta}f(A'') - \frac{\mathrm{d}\theta}{\mathrm{d}\lambda}v_{CR}\lambda\mu_0 < (\theta - 1)v_{CR}\mu_0$.

$\frac{d\overline{A}}{d\lambda} < 0$ if and only if $\frac{\mathrm{d}\Delta f\left(F^{-1}(s)\right)}{\mathrm{d}\lambda} - \frac{\mathrm{d}\theta}{\mathrm{d}\lambda}v_{CR}\lambda\mu_0 > (\theta - 1)v_{CR}\mu_0$.

(d) An observation of Lemma 5.3.

(Q.E.D.)

C1. 8. Proof of Lemma 5.5. It is similar to the proof of Lemma 5.4.

C1. 9. Proof of Lemma 5.6. It is similar to the proof of Lemma 5.4.

Appendix C2-Supplementary Figures (Different Scenarios of Numerical Analysis)

Scenario A

p=22, c=5.5, m=2, v_{UU}=1, v_{CR}=0.5, μ_0=12, d_0=14, δ=2, λ=0.2

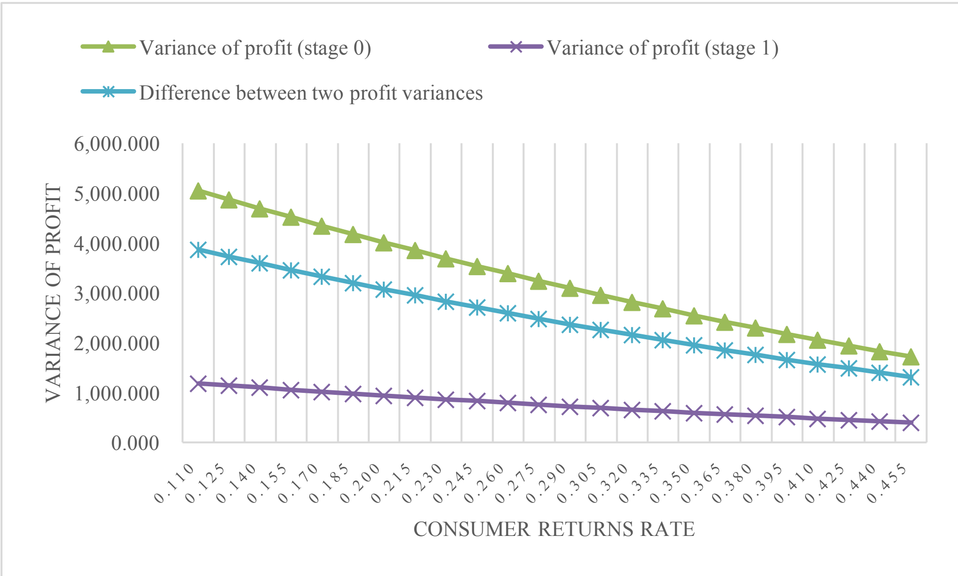

Figure A1. *Impacts of an increased consumer returns rate on the profit variance of the whole channel under a centralized supply chain structure*

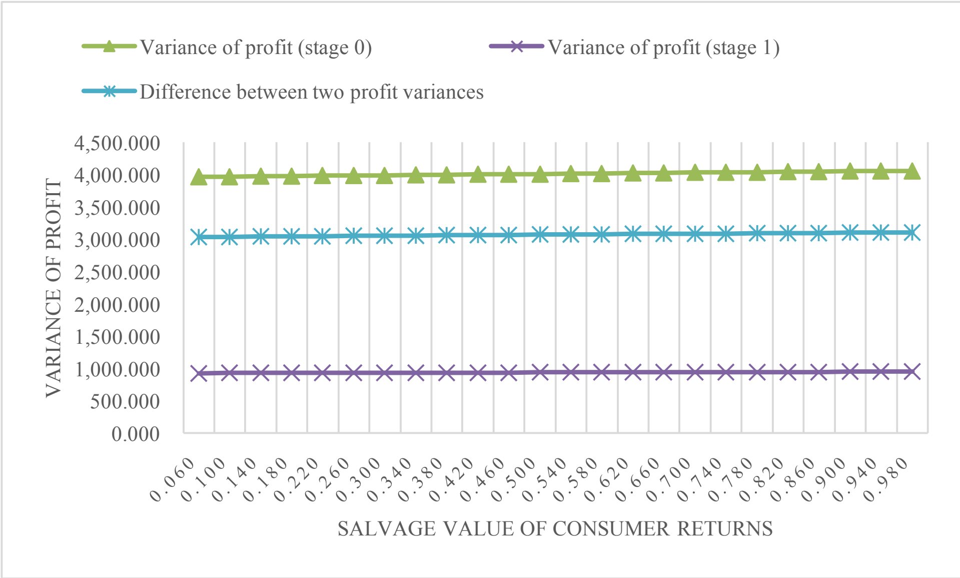

Figure A2. *Impacts of an increased salvage value of consumer returns on the profit variance of the whole channel under a centralized supply chain structure*

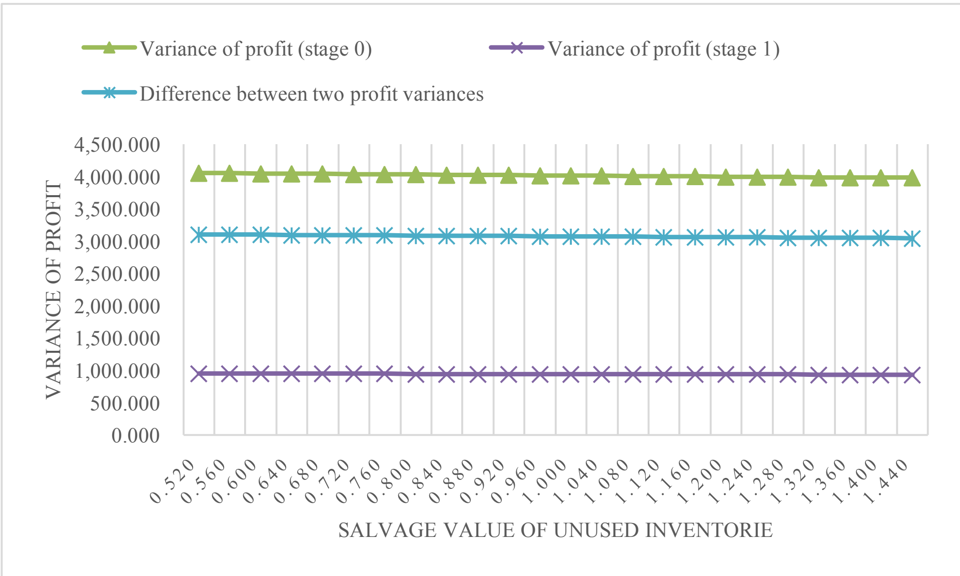

Figure A3. *Impacts of an increased salvage value of unused inventories on the profit variance of the whole channel under a centralized supply chain structure*

Scenario B

p=***37.5***, c=***12.5***, m=***5***, v_{UU}=**1.5**, v_{CR}=***0.8***, μ_0=***35***, d_0=***100***, δ=***25***, λ=***0.38***

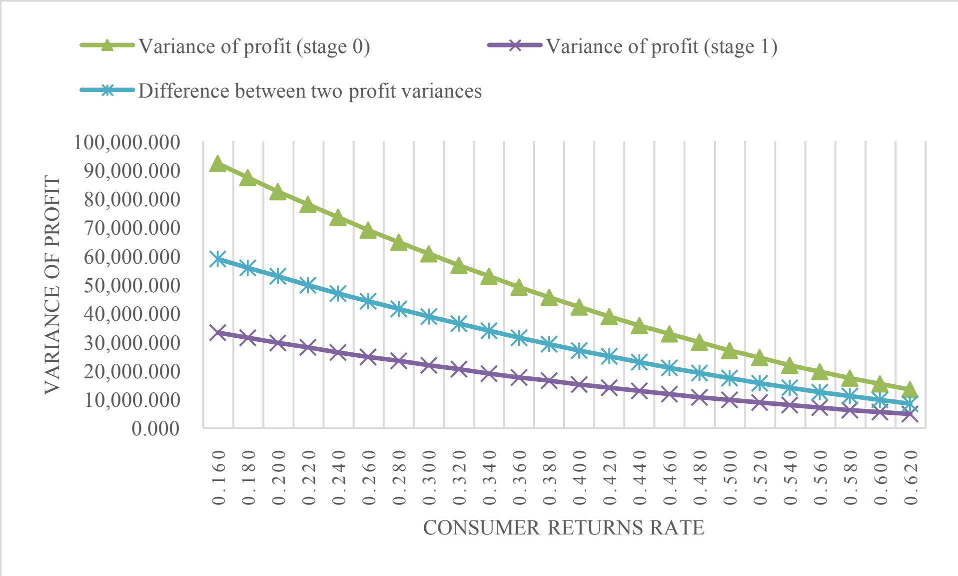

Figure B1. *Impacts of an increased consumer returns rate on the profit variance of the whole channel under a centralized supply chain structure*

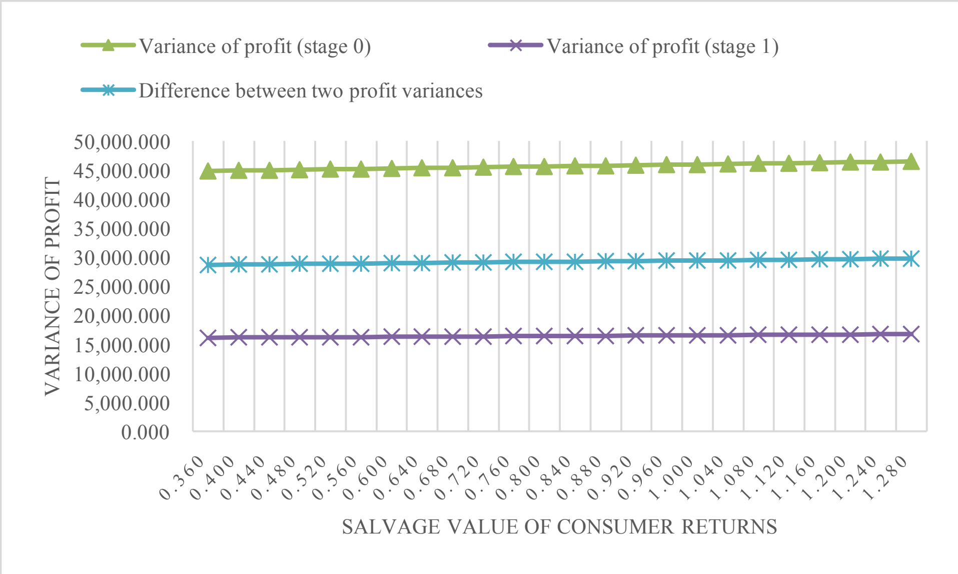

Figure B2. *Impacts of an increased salvage value of consumer returns on the profit variance of the whole channel under a centralized supply chain structure*

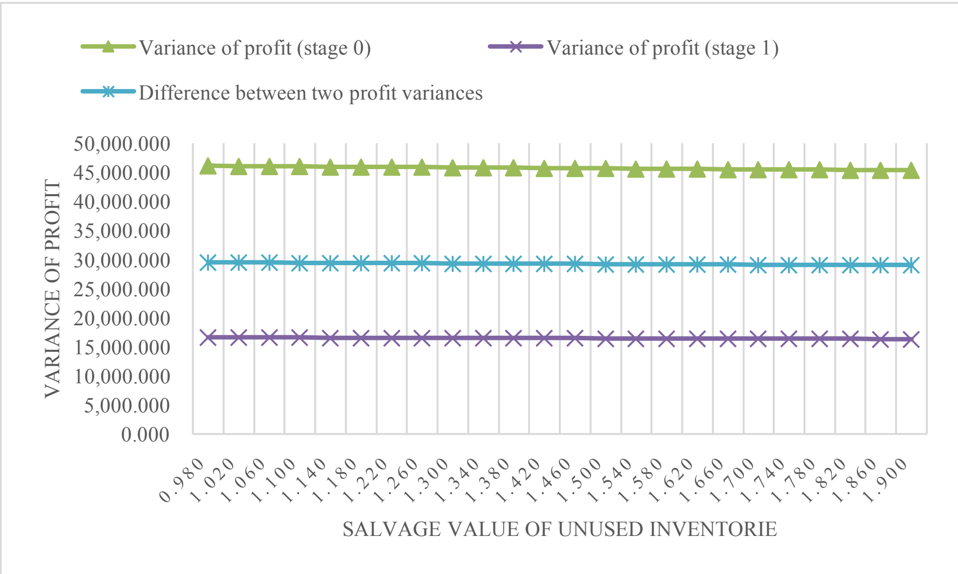

Figure B3. *Impacts of an increased salvage value of unused inventories on the profit variance of the whole channel under a centralized supply chain structure*

Scenario C

***p*=22, *c*=13, *m*=9, v_{UU}=3, v_{CR}=1.5, μ_0=12, d_0=14, δ=2, λ=0.2**

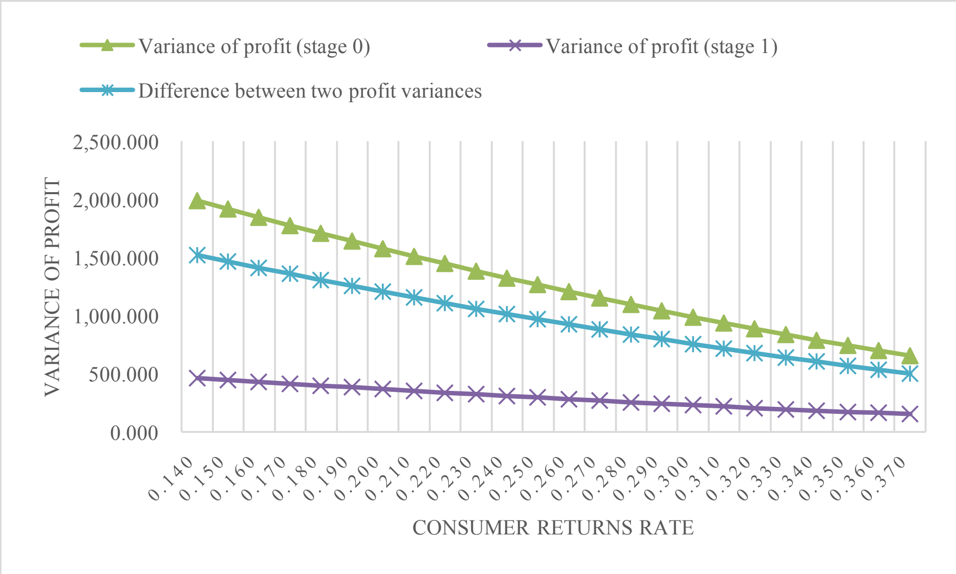

Figure C1. *Impacts of an increased consumer returns rate on the profit variance of the whole channel under a centralized supply chain structure*

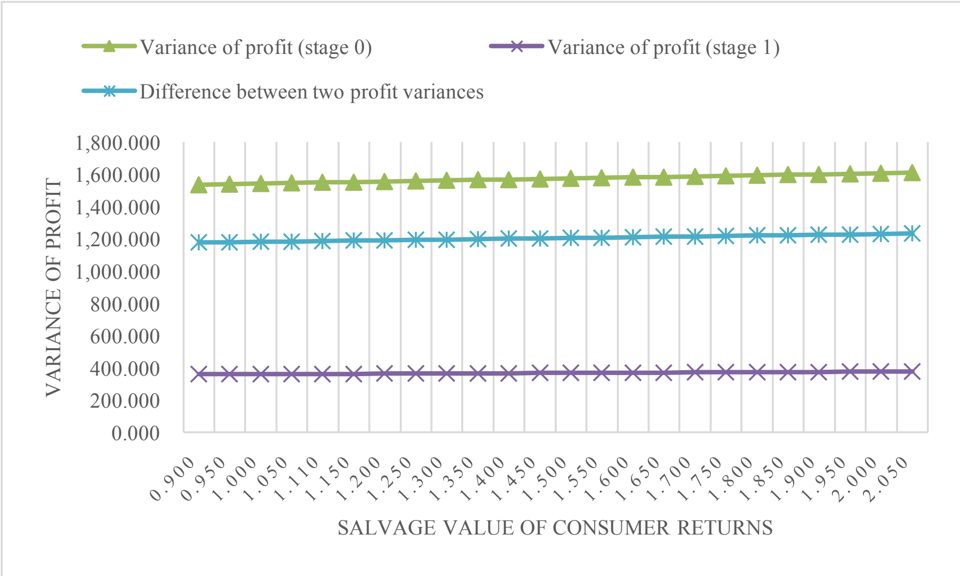

Figure C2. *Impacts of an increased salvage value of consumer returns on the profit variance of the whole channel under a centralized supply chain structure*

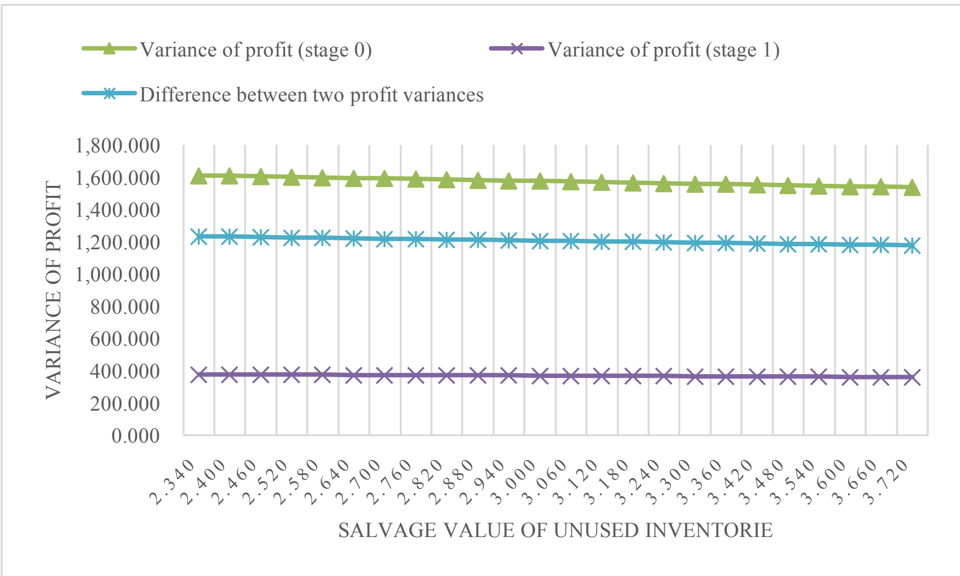

Figure C3. *Impacts of an increased salvage value of unused inventories on the profit variance of the whole channel under a centralized supply chain structure*

Scenario D

p=*41.5*, c=*21*, m=*14.5*, v_{UU}=**5**, v_{CR}=*2*, μ_0=*35*, d_0=*100*, δ=*25*, λ=*0.38*

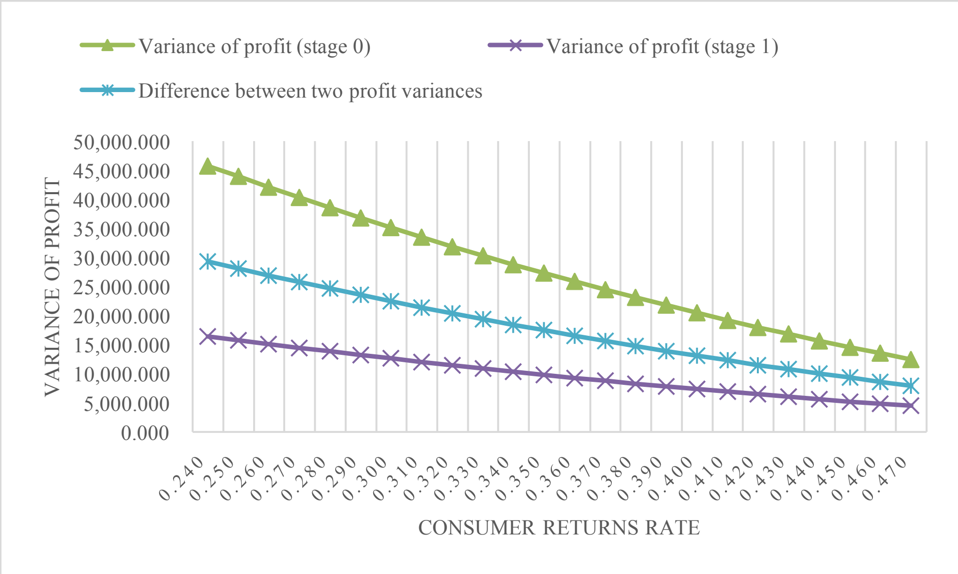

Figure D1. *Impacts of an increased consumer returns rate on the profit variance of the whole channel under a centralized supply chain structure*

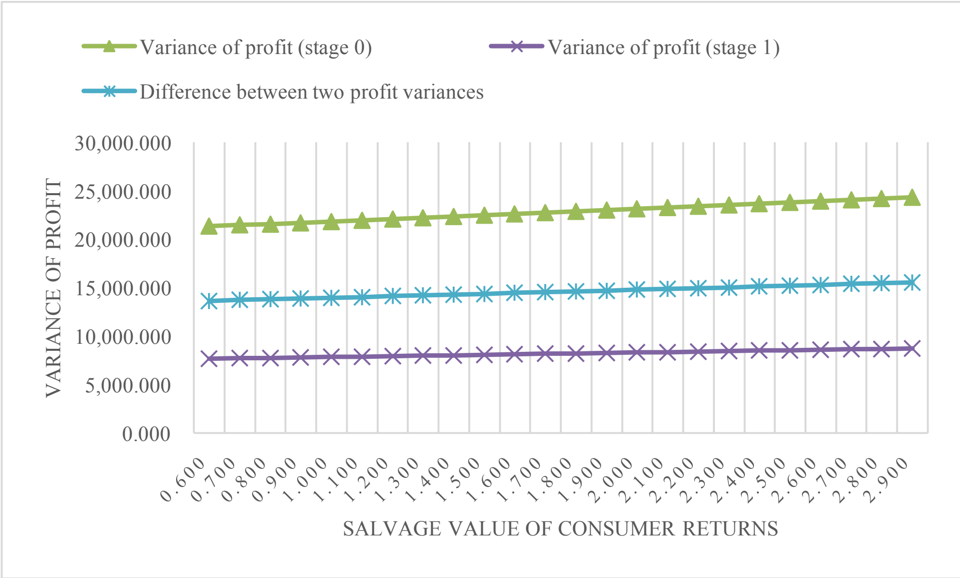

Figure D2. *Impacts of an increased salvage value of consumer returns on the profit variance of the whole channel under a centralized supply chain structure*

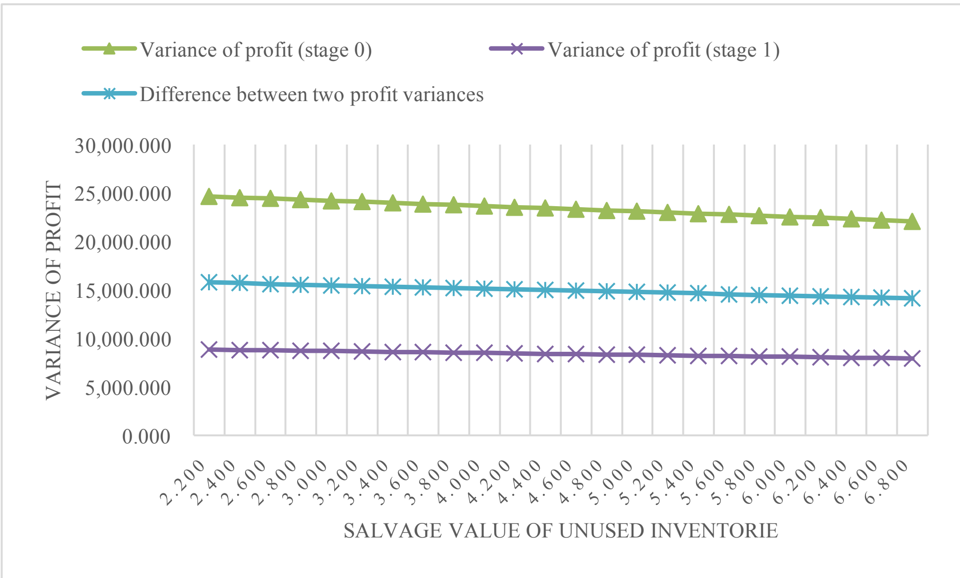

Figure D3. *Impacts of an increased salvage value of unused inventories on the profit variance of the whole channel under a centralized supply chain structure*

References

Akkermans, H. A., P. Bogerd, E. Yücesan, and L. N. Van Wassenhove, 2003. The impact of ERP on supply chain management: Exploratory findings from a European Delphi study. *European Journal of Operational Research*, 146(2), 284-301.

Alptekinoğlu, A., and C. J. Corbett, 2008. Mass customization vs. mass production: Variety and price competition. *Manufacturing & Service Operations Management*, 10(2), 204-217.

Altonen, A., 2011. Success factors of mass customization–Cases: Chocri and Shoes of Prey.

Arcelus, F. J., S. Kumar, and G. Srinivasan, 2011. Channel coordination with manufacturer's return policies within a newsvendor framework. *4OR*, 9(3), 279-297.

Arani, H. V., M. Rabbani, and H. Rafiei, 2016. A revenue-sharing option contract toward coordination of supply chains. *International Journal of Production Economics*, 178, 42-56.

Arshinder, K., A. Kanda, and S. G. Deshmukh, 2009. A coordination theoretic model for three level supply chains using contracts. *Sadhana*, 34(5), 767-798.

Asian, S., and X. Nie, 2014. Coordination in supply chains with uncertain demand and disruption risks: existence, analysis, and insights. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 44(9), 1139-1154.

Atasu, A., L. B. Toktay, and L. N Van Wassenhove, 2013. How collection cost structure drives a manufacturer's reverse channel choice. *Production and Operations Management*, 22(5), 1089-1102.

Bateman, R. J., and K. Cheng, 2006. Extending the product portfolio with 'devolved manufacturing': Methodology and case studies. *International Journal of Production Research*, 44(16), 3325-3343.

Baena, V., 2016. The next revolution in mass customization: An insight into the sneaker market. *International Journal of Marketing*, Communication and

New Media, 4(6).

Bhattacharya, S., V. D. R. Guide Jr, and L. N. Van Wassenhovee, 2006. Optimal order quantities with remanufacturing across new product generations. *Production and Operations Management*, 15(3), 421-431.

Bose, I., and P. Anand, 2007. On returns policies with exogenous price. *European Journal of Operational Research*, 178(3), 782-788.

Brabazon, P. G., B.L. MacCarthy, A. Woodcock, and R. W. Hawkins, 2010. Mass customization in the automotive industry: Comparing interdealer trading and reconfiguration flexibilities in order fulfillment. *Production and Operations Management*, 19(5), 489-502.

Chen, H.Y., J. Chen, and Y.H.F. Chen, 2006. A coordination mechanism for a supply chain with demand information updating. *International Journal of Production Economics*, 103(1), 347-361.

Chen, H.Y., Y. F. Chen, C. H. Chiu, T. M. Choi, and S. Sethi, 2010. Coordination mechanism for the supply chain with leadtime consideration and price-dependent demand. *European Journal of Operational Research*, 203(1), 70-80.

Chen, J., 2011. The impact of sharing customer returns information in a supply chain with and without a buyback policy. *European Journal of Operational Research*, 213(3), 478-488.

Chen, J., and P. C. Bell, 2009. The impact of customer returns on pricing and order decisions. *European Journal of Operational Research*, 195(1), 280-295.

Chen, J., and P. C. Bell, 2011. Coordinating a decentralized supply chain with customer returns and price-dependent stochastic demand using a buyback policy. *European Journal of Operational Research*, 212(2), 293-300.

Chen, J. M., and C. I. Chang, 2014. Coordinating a closed-loop supply chain using a bargaining power approach. *International Journal of Systems Science: Operations & Logistics*, 1(2), 69-83.

Chen, X.F., and G.H. Wan, 2011. The effect of financing on a budget-constrained supply chain under wholesale price contract. *Asia-Pacific Journal of*

Operational Research, 28(04), 457-485.

Chen, K.B., and T.J. Xiao, 2009. Demand disruption and coordination of the supply chain with a dominant retailer. *European Journal of Operational Research*, 197(1), 225-234.

Chen, X., and Q. Zhou, 2014. Loss-averse retailer's optimal ordering policies for perishable products with customer returns. *Mathematical Problems in Engineering*, 831796.

Chiu, C. H., T. M. Choi, and C. S. Tang, 2011. Price, rebate, and returns supply contracts for coordinating supply chains with price-dependent demands. *Production and Operations Management*, 20(1), 81-91.

Choi, T.M., 2013. Optimal return service charging policy for fashion mass customization program. *Service Science*, 5, 56-68.

Choi, T.M., 2016. Supply chain systems coordination with multiple risk sensitive retail buyers. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 46, 636-645.

Choi, T. M., 2014a. Fashion retail supply chain management: A systems optimization approach. *CRC Press*.

Choi, T. M. (Ed.)., 2014b. Fast fashion systems: Theories and applications. *CRC Press*.

Choi, T. M., and S. Guo, 2018. Responsive supply in fashion mass customisation systems with consumer returns. *International Journal of Production Research*, 56(10), 3409-3422.

Choi, T. M., and P. S. Chow, 2008. Mean-variance analysis of quick response program. *International Journal of Production Economics*, 114(2), 456-475.

Choi, T. M., D. Li, and H. Yan, 2003. Optimal two-stage ordering policy with Bayesian information updating. *Journal of the Operational Research Society*, 54(8), 846-859.

Choi, T. M., D. Li, H. Yan, and C. H. Chiu, 2008. Channel coordination in supply chains with agents having mean-variance objectives. *Omega*, 36(4), 565-576.

Choi, T. M., Y. Li, and L. Xu, 2013a. Channel leadership, performance and coordination in closed loop supply chains. *International Journal of Production Economics*, 146(1), 371-380.

Choi, T. M., N. Liu, S.Y. Ren, and C. L. Hui, 2013b. No refund or full refund: When should a fashion brand offer full refund consumer return service for mass customization products. *Mathematical Problems in Engineering*, 561846.

Chow, P. S., T. M. Choi, and T. C. E. Cheng, 2012. Impacts of minimum order quantity on a quick response supply chain. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, 42(4), 868-879.

Crocker, K. J., and P. Letizia, 2014. Optimal policies for recovering the value of consumer returns. *Production and Operations Management*, 23(10), 1667-1680.

Daaboul, J., C. Da Cunha, A. Bernard, and F. Laroche, 2011. Design for mass customization: Product variety vs. process variety. *CIRP Annals-Manufacturing Technology*, 60(1), 169-174.

De Giovanni, P., 2014. Environmental collaboration in a closed-loop supply chain with a reverse revenue sharing contract. *Annals of Operations Research*, 220(1), 135-157.

Da Silveira, G., D. Borenstein, and F. S. Fogliatto, 2001. Mass customization: Literature review and research directions. *International Journal of Production Economic*s, 72(1), 1-13.

Dean, P. R., Y. L. Tu, and D. Xue, 2009. An information system for one-of-a-kind production. *International Journal of Production Research*, 47(4), 1071-1087.

Ding, D., and J. Chen, 2008. Coordinating a three level supply chain with flexible return policies. *Omega*, 36(5), 865-876.

Dobos, I., B. Gobsch, N. Pakhomova, G. Pishchulov, and K. Richter, 2013. Design of contract parameters in a closed-loop supply chain. *Central European Journal of Operations Research*, 21(4), 713-727.

Donohue, K. L., 2000. Efficient supply contracts for fashion goods with forecast updating and two production modes. *Management Science*, 46(11), 1397-

1411.

Du, F., and G. W. Evans, 2008. A bi-objective reverse logistics network analysis for post-sale service. *Computers & Operations Research*, 35(8), 2617-2634.

Du, S.C., R. Xu, and L. Li, 2016. Modeling and analysis of multiproduct multistage manufacturing system for quality improvement. *IEEE Transactions on Systems, Man, and Cybernetics: Systems,* published online, DOI: https://doi.org/10.1109/TSMC.2016.2614766.

Dubey, R., A. Gunasekaran, T. Papadopoulos, S. J. Childe, K. T. Shibin, and S. F. Wamba, 2017. Sustainable supply chain management: Framework and further research directions. *Journal of Cleaner Production*, 142, 1119-1130.

Duray, R., P. T. Ward, G. W. Milligan, and W. L. Berry, 2000. Approaches to mass customization: Configurations and empirical validation. *Journal of Operations Management*, 18(6), 605-625.

Ferguson, M., V. D. R. Guide Jr, and G. C. Souza, 2006. Supply chain coordination for false failure returns. *Manufacturing & Service Operations Management*, 8(4), 376-393.

Fogliatto, F. S., G. J. Da Silveira, and D. Borenstein, 2012. The mass customization decade: An updated review of the literature. *International Journal of Production Economics*, 138(1), 14-25.

Forza, C., and F. Salvador, 2008. Application support to product variety management. *International Journal of Production Research*, 46(3), 817-836.

Gao, J.H., H.S. Han, L.T. Hou, and H.Y. Wang, 2016. Pricing and effort decisions in a closed-loop supply chain under different channel power structures. *Journal of Cleaner Production*, 112, 2043-2057.

Genc, T. S., and P. De Giovanni, 2017. Trade-in and save: A two-period closed-loop supply chain game with price and technology dependent returns. *International Journal of Production Economics*, 183, 514-527.

Ghoreishi, M., A. Mirzazadeh, and G. W. Weber, 2014. Optimal pricing and ordering policy for non-instantaneous deteriorating items under inflation and customer returns. *Optimization*, 63(12), 1785-1804.

Ghoreishi, M., A. Mirzazadeh, G. W. Weber, and I. Nakhai-Kamalabadi, 2015. Joint pricing and replenishment decisions for non-instantaneous deteriorating items with partial backlogging, inflation-and selling price-dependent demand and customer returns. *Journal of Industrial and Management Optimization*, 11(3), 933-949.

Giri, B. C., B. Roy, and T. Maiti, 2017. Multi-manufacturer pricing and quality management strategies in the presence of brand differentiation and return policy. *Computers & Industrial Engineering*, 105, 146-157.

Govindan, K., and M. N. Popiuc, 2014. Reverse supply chain coordination by revenue sharing contract: A case for the personal computers industry. *European Journal of Operational Research*, 233(2), 326-336.

Gu, Q.L., and G. Tagaras, 2014. Optimal collection and remanufacturing decisions in reverse supply chains with collector's imperfect sorting. *International Journal of Production Research*, 52(17), 5155-5170.

Gu, X. J., G. N. Qi, Z. X. Yang, and G. J. Zheng, 2002. Research of the optimization methods for mass customization (MC). *Journal of Materials Processing Technology*, 129(1), 507-512.

Guide, V. D. R., V. Jayaraman, and J. D. Linton, 2003. Building contingency planning for closed-loop supply chains with product recovery. *Journal of operations Management*, 21(3), 259-279.

Guo, S., T. M. Choi, B. Shen, and S. Jung, 2018a. Coordination and enhancement schemes for quick response mass customization supply chains with consumer returns and salvage value considerations. *IEEE Transactions on Systems, Man, and Cybernetics – Systems*, in press.

Guo, S., T. M. Choi, B. Shen, and S. Jung, 2018b. Inventory management in mass customization operations: A review. *IEEE Transactions on Engineering Management*, in press.

Guo, S., B. Shen, T. M. Choi, and S. Jung, 2017. A review on supply chain contracts in reverse logistics: Supply chain structures and channel leaderships. *Journal of Cleaner Production*, 144, 387-402.

He, J., K. S. Chin, J. B. Yang, and D. L. Zhu, 2006. Return policy model of supply chain management for single-period products. *Journal of Optimization Theory and Applications*, 129(2), 293-308.

He, Y.J., 2015. Acquisition pricing and remanufacturing decisions in a closed-loop supply chain. *International Journal of Production Economic*s, 163, 48-60.

He, Y.J., and J. Zhang, 2010. Random yield supply chain with a yield dependent secondary market. *European Journal of Operational Research*, 206(1), 221-230.

He, Z., T.C.E. Cheng, J. Dong, and S. Wang, 2014. Evolutionary location and pricing strategies in competitive hierarchical distribution systems: A spatial agent-based model. *IEEE Transactions on Systems, Man, and Cybernetics – Systems*, 44(7), 822-833.

Heradio, R., H. Perez-Morago, M. Alférez, D. Fernandez-Amoros, and G. H. Alférez, 2016. Augmenting measure sensitivity to detect essential, dispensable and highly incompatible features in mass customization. *European Journal of Operational Research*, 248(3), 1066-1077.

Hong, I. H., J. C. Ammons, and M. J. Realff, 2008. Decentralized decision-making and protocol design for recycled material flows. *International Journal of Production Economics*, 116(2), 325-337.

Hong, I. H., and J. S. Yeh, 2012. Modeling closed-loop supply chains in the electronics industry: A retailer collection application. *Transportation Research Part E: Logistics and Transportation Review*, 48(4), 817-829.

Hong, X.P., L. Xu, P. Du, and W.J. Wang, 2015. Joint advertising, pricing and collection decisions in a closed-loop supply chain. *International Journal of Production Economics*, 167, 12-22.

Hou, J., A. Z. Zeng, and L.D. Zhao, 2010. Coordination with a backup supplier through buy-back contract under supply disruption. T*ransportation Research Part E: Logistics and Transportation Review*, 46(6), 881-895.

Hsuan-Mikkola, J., and T. Skjøtt-Larsen, 2004. Supply-chain integration: Implications for mass customization, modularization and postponement strategies. *Production Planning & Control*, 15(4), 352-361.

Hu, S., Y. Dai, Z. J. Ma, and Y. S. Ye, 2016. Designing contracts for a reverse supply chain with strategic recycling behavior of consumers. *International Journal of Production Economics*, 180, 16-24.

Hu, W., Y. Li, and K. Govindan 2014. The impact of consumer returns policies on consignment contracts with inventory control. *European Journal of Operational Research*, 233(2), 398-407.

Huang, M. H., and R. T. Rust, 2011. Sustainability and consumption. *Journal of the Academy of Marketing Science*, 39(1), 40-54.

Huang, M., P.X. Yi, T.L. Shi, and L.J. Guo, 2015. A modal interval based method for dynamic decision model considering uncertain quality of used products in remanufacturing. *Journal of Intelligent Manufacturing*, 1-11.

Huang, X.M., S. M. Choi, W. K. Ching, T. K. Siu, and M. Huang, 2011. On supply chain coordination for false failure returns: A quantity discount contract approach. *International Journal of Production Economics*, 133(2), 634-644.

Huang, X.M., J. W. Gu, W. K. Ching, and T. K. Siu, 2014. Impact of secondary market on consumer return policies and supply chain coordination. *Omega*, 45, 57-70.

Huang, Y.T., and Z.J. Wang, 2017. Closed-loop supply chain models with product take-back and hybrid remanufacturing under technology licensing. *Journal of Cleaner Production*, 142, 3917-3927.

Huang, Z.M., S. X. Li, and V. Mahajan, 2002. An analysis of manufacturer-retailer supply chain coordination in cooperative advertising. *Decision Sciences*, 33(3), 469-494.

Iyer, A. V., and M. E. Bergen, 1997. Quick response in manufacturer-retailer channels. *Management Science*, 43(4), 559-570.

Jacobs, B. W., and R. Subramanian, 2012. Sharing responsibility for product recovery across the supply chain. *Production and Operations Management*, 21(1), 85-100.

Jena, S. K., and S. P. Sarmah, 2016. Price and service co-opetiton under uncertain demand and condition of used items in a remanufacturing system. *International Journal of Production Economics*, 173, 1-21.

Jeong, I. J., 2012. A centralized/decentralized design of a full return contract for a risk-free manufacturer and a risk-neutral retailer under partial information sharing. *International Journal of Production Economics*, 136(1), 110-115.

Jiang, K., H. L. Lee, and R. W. Seifert, 2006. Satisfying customer preferences via mass customization and mass production. *IIE Transactions*, 38(1), 25-38.

Jiao, J.X., L.F. Zhang, and S. Pokharel, 2007. Process platform planning for variety coordination from design to production in mass customization manufacturing. *IEEE Transactions on Engineering Management*, 54(1), 112-129.

Kang, C. M., and Y. S. Hong, 2009. A framework for designing balanced product platforms by estimating the versatility of components. *International Journal of Production Research*, 47(19), 5271-5295.

Karpowitz, D. J., J. J. Cox, J. C. Humpherys, and S. C. Warnick, 2008. A dynamic workflow framework for mass customization using web service and autonomous agent techniques. *Journal of Intelligent Manufacturing*, 19(5),537-552.

Kaya, O., 2010. Incentive and production decisions for remanufacturing operations. *European Journal of Operational Research*, 201(2), 442-453.

Köksal, D., J. Strähle, M. Müller, and M. Freise, 2017. Social sustainable supply chain management in the textile and apparel industry—A literature review. *Sustainability*, 9(1), 100.

Krumwiede, D. W., and C. Sheu, 2002. A model for reverse logistics entry by third-party providers. *Omega*, 30(5), 325-333.

Kumar, S., and P. Malegeant, 2006. Strategic alliance in a closed-loop supply chain, a case of manufacturer and eco-non-profit organization. *Technovation*, 26(10), 1127-1135.

Kuo, T. C., 2013. Mass customization and personalization software development: A case study eco-design product service system. *Journal of Intelligent Manufacturing*, 24(5), 1019-1031.

Kurata, H., and X. Yue, 2008. Trade promotion mode choice and information sharing in fashion retail supply chains. *International Journal of Production Economics*, 114(2), 507-519.

Lambert, D. M., and M. C. Cooper, 2000. Issues in supply chain management. *Industrial Marketing Management*, 29(1), 65-83.

Lee, C. H., and B. D. Rhee, 2007. Channel coordination using product returns for a supply chain with stochastic salvage capacity. *European Journal of Operational Research*, 177(1), 214-238.

Lee, C. K. H., K. L. Choy, G. T. Ho, K. S. Chin, K. M. Y. Law, and Y. K. Tse, 2013. A hybrid OLAP-association rule mining based quality management system for extracting defect patterns in the garment industry. *Expert Systems with Applications*, 40(7), 2435-2446.

Leitao, P., A. W. Colombo, and F. J. Restivo, 2005. ADACOR: A collaborative production automation and control architecture. *IEEE Intelligent Systems*, 20(1), 58-66.

Li, J., Z. Wang, B. Jiang, and T. Kim, 2017. Coordination strategies in a three-echelon reverse supply chain for economic and social benefit. *Applied Mathematical Modelling*, 49, 599-611.

Li, X., and Y. Li, 2016. Chain-to-chain competition on product sustainability. *Journal of Cleaner Production*, 112, 2058-2065.

Li, X., Y. Li, and X.Q. Cai, 2012a. Quantity decisions in a supply chain with early returns remanufacturing. *International Journal of Production Research*, 50(8), 2161-2173.

Li, Y., C.S. Wei, and X.Q. Cai, 2012b. Optimal pricing and order policies with B2B product returns for fashion products. *International Journal of Production Economics*, 135(2), 637-646.

Li, J., T.M. Choi, and T.C.E. Cheng, 2014. Mean variance analysis of fast fashion supply chains with returns policy. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 44(4), 422 – 434.

Li, J.Z., C.L. Liu, and W.C. Xiao, 2016. Modularity, lead time and return policy for supply chain in mass customization system. *International Journal of Computational Intelligence Systems*, 9(6), 1133-1153.

Liao, K., X.D. Deng, and E. Marsillac, 2013. Factors that influence Chinese automotive suppliers' mass customization capabilities. *International Journal of Production Economics*, 146(1), 25-36.

Liu, B., J. Chen, S. Liu, and R. Zhang, 2006. Supply-chain coordination with combined contract for a short-life-cycle product. *IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans*, 36(1), 53-61.

Liu, J., B. Mantin, and H.Y. Wang, 2014. Supply chain coordination with customer returns and refund-dependent demand. *International Journal of Production Economics*, 148, 81-89.

Liu, N., T. M. Choi, C. W. M. Yuen, and F. Ng, 2012. Optimal pricing, modularity, and return policy under mass customization. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, 42(3), 604-614.

Mafakheri, F., and F. Nasiri, 2013. Revenue sharing coordination in reverse logistics. *Journal of Cleaner Production*, 59, 185-196.

Markowitz, H.M., 1959. Portfolio selection: Efficient diversification of investment. *John Wiley & Sons*, New York.

Matsui, K., 2010. Returns policy, new model introduction, and consumer welfare. *International Journal of Production Economics*, 124(2), 299-309.

Min, H., and G.G. Zhou, 2002. Supply chain modeling: Past, present and future. *Computers & industrial engineering*, 43(1), 231-249.

Mollenkopf, D. A., R. Frankel, and I. Russo, 2011. Creating value through returns management: Exploring the marketing–operations interface. *Journal of Operations Management*, 29(5), 391-403.

Nair, A., and D. J. Closs, 2006. An examination of the impact of coordinating supply chain policies and price markdowns on short lifecycle product retail performance. *International Journal of Production Economics*, 102(2), 379-392.

Ni, M., X. Xu, and S. Deng, 2007. Extended QFD and data-mining-based methods for supplier selection in mass customization. *International Journal of Computer Integrated Manufacturing*, 20(2-3), 280-291.

Ohmura, S., and H. Matsuo, 2016. The effect of risk aversion on distribution channel contracts: Implications for return policies. *International Journal of Production Economics*, 176, 29-40.

Pinçe, Ç., M. Ferguson, and B. Toktay, 2016. Extracting maximum value from consumer returns: Allocating between remarketing and refurbishing for warranty claims. *Manufacturing & Service Operations Management*, 18(4), 475-492.

Pollard, D., S. Chuo, and B. Lee, 2016. Strategies for mass customization. *Journal of Business & Economics Research (Online)*, 14(3), 101.

Ramanathan, R., 2011. An empirical analysis on the influence of risk on relationships between handling of product returns and customer loyalty in E-commerce. *International Journal of Production Economics*, 130(2), 255-261.

Ran, W.X., F. Chen, Q.N. Wu, and S. Liu, 2016. A study of the closed-loop supply chain coordination on waste glass bottles recycling. *Mathematical Problems in Engineering*, 1049514.

Ro, Y. K., J. K. Liker, and S. K. Fixson, 2007. Modularity as a strategy for supply chain coordination: The case of US auto. *IEEE Transactions on Engineering Management*, 54(1), 172-189.

Ruiz-Benitez, R., and A. Muriel, 2014. Consumer returns in a decentralized supply chain. *International Journal of Production Economics*, 147, 573-592.

Rungtusanatham, M. J., and F. Salvador, 2008. From mass production to mass customization: Hindrance factors, structural inertia, and transition hazard. *Production and Operations Management*, 17(3), 385-396.

Sarker, B. R., 2014. Consignment stocking policy models for supply chain systems: A critical review and comparative perspectives. *International Journal of Production Economics*, 155, 52-67.

Savaskan, R. C., and L. N. Van Wassenhove, 2006. Reverse channel design: the case of competing retailers. *Management Science*, 52(1), 1-14.

Salvador, F., and C. Forza, 2004. Configuring products to address the customization-responsiveness squeeze: A survey of management issues and opportunities. *International Journal of Production Economics*, 91(3), 273-291.

Schöggl, J. P., R. J. Baumgartner, and Hofer, D., 2017. Improving sustainability performance in early phases of product design: A checklist for sustainable product development tested in the automotive industry. *Journal of Cleaner Production*, 140, 1602-1617.

Selladurai, R. S., 2004. Mass customization in operations management: Oxymoron or reality. *Omega*, 32(4), 295-300.

Shao, X. F., and J. H. Ji, 2008. Evaluation of postponement strategies in mass customization with service guarantees. *International Journal of Production Research*, 46(1), 153-171.

Shen, B., T.M. Choi, Y. Wang, and C.K.Y. Lo, 2013. The coordination of fashion supply chains with a risk-averse supplier under the markdown money policy. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 43(2), 266-276.

Shen, B., P. S. Chow, and T. M. Choi, 2014. Supply chain contracts in fashion department stores: Coordination and risk analysis. *Mathematical Problems in Engineering*, 954235.

Shen, B., R.R. Qian, and T. M. Choi, 2017. Selling luxury fashion online with social influences considerations: Demand changes and supply chain coordination. *International Journal of Production Economics*, 185, 89-99.

Sheu, J. B., Y. H. Chou, and C. C. Hu, 2005. An integrated logistics operational model for green-supply chain management. *Transportation Research Part E: Logistics and Transportation Review*, 41(4), 287-313.

Shi, C. S., 2006. General return contracts for style goods: Expected utility approach. *Production Planning & Control*, 17(5), 508-517.

Shi, X.T., Y. Qian, and C.W. Dong, 2017. Economic and environmental performance of fashion supply chain: The joint effect of power structure and sustainable investment. *Sustainability*, 9(6), 961.

Shulman, J. D., A. T. Coughlan, and R. C. Savaskan, 2011. Managing consumer returns in a competitive environment. *Management Science*, 57(2), 347-362.

Song, Y.Y., S. Ray, and S.L. Li, 2008. Structural properties of buyback contracts for price-setting newsvendors. *Manufacturing & Service Operations Management*, 10(1), 1-18.

Squire, B., S. Brown, J. Readman, and J. Bessant, 2006. The impact of mass customisation on manufacturing trade-offs. *Production and Operations Management*, 15(1), 10-21.

Su, J. C., Y. L. Chang, and M. Ferguson, 2005. Evaluation of postponement structures to accommodate mass customization. J*ournal of Operations Management*, 23(3), 305-318.

Su, X.M., 2009. Consumer returns policies and supply chain performance. *Manufacturing & Service Operations Management*, 11(4), 595-612.

Sundarakani, B., R. De Souza, M. Goh, S. M. Wagner, and S. Manikandan, 2010. Modeling carbon footprints across the supply chain. *International Journal of Production Economics*, 128(1), 43-50.

Tien, J. M., 2011. Manufacturing and services: From mass production to mass customization. *Journal of Systems Science and Systems Engineering*, 20(2), 129-154.

Tseng, M. M., M. Lei, C.J. Su, and M. E. Merchant, 1997. A collaborative control system for mass customization manufacturing. *CIRP Annals-Manufacturing Technology*, 46(1), 373-376.

Ülkü, M. A., and J. Hsuan, 2017. Towards sustainable consumption and production: Competitive pricing of modular products for green consumers. *Journal of*

Cleaner Production, 142, 4230-4242.

Vachon, S., and R. D. Klassen, 2008. Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics*, 111(2), 299-315.

Wang, F., X.P. Zhuo, and B.Z. Niu, 2016. Sustainability analysis and buy-back coordination in a fashion supply chain with price competition and demand uncertainty. *Sustainability*, 9(1), 25.

Wang, X.L., and L.W. Liu, 2007. Coordination in a retailer-led supply chain through option contract. *International Journal of Production Economics*, 110(1), 115-127.

Wei, Y., and L. Xiong, 2015. Contracting fashion products supply chains when demand is dependent on price and sales effort. *Mathematical Problems in Engineering*, 161486.

Weraikat, D., M. K. Zanjani, and N. Lehoux, 2016. Coordinating a green reverse supply chain in pharmaceutical sector by negotiation. *Computers & Industrial Engineering*, 93, 67-77.

Wu, D.S., 2013. Coordination of competing supply chains with news-vendor and buyback contract. *International Journal of Production Economics*, 144(1), 1-13.

Wu, H.Y., X.H. Han, Q.X. Yang, and X.J. Pu, 2015. Production and coordination decisions in a closed-loop supply chain with remanufacturing cost disruptions when retailers compete. *Journal of Intelligent Manufacturing*, 1-9.

Xiao, T.J., T. M. Choi, and T. C. E. Cheng, 2014. Product variety and channel structure strategy for a retailer-Stackelberg supply chain. *European Journal of Operational Research*, 233(1), 114-124.

Xiao, T.J., and J. Shi, 2016. Consumer returns reduction and information revelation mechanism for a supply chain. *Annals of Operations Research*, 240(2), 661-681.

Xiao, T.J., K.R. Shi, and D.Q. Yang, 2010. Coordination of a supply chain with consumer return under demand uncertainty. *International Journal of Production Economics*, 124(1), 171-180.

Xie, J.P., L. Liang, L.H. Liu, and P. Ieromonachou, 2017. Coordination contracts of dual-channel with cooperation advertising in closed-loop supply chains. *International Journal of Production Economics*, 183, 528-538.

Xu, L., Y. Li, K. Govindan, and X.L. Xu, 2015. Consumer returns policies with endogenous deadline and supply chain coordination. *European Journal of Operational Research*, 242(1), 88-99.

Xu, M., Q. Wang, and L. Ouyang, 2013. Coordinating contracts for two-stage fashion supply chain with risk-averse retailer and price-dependent demand. *Mathematical Problems in Engineering*, 259164.

Yan, N. N., and B. W. Sun, 2012. Optimal Stackelberg strategies for closed-loop supply chain with third-party reverse logistics. *Asia-Pacific Journal of Operational Research*, 29(05), 1250026.

Yang, D., T. M. Choi, T. Xiao, and T. C. E. Cheng, 2011. Coordinating a two-supplier and one-retailer supply chain with forecast updating. *Automatica*, 47(7), 1317-1329.

Yao, Z., S. C. Leung, and K. K. Lai, 2008. Analysis of the impact of price-sensitivity factors on the returns policy in coordinating supply chain. *European Journal of Operational Research*, 187(1), 275-282.

Ye, Y. S., Z. J. Ma, and Y. Dai, 2016. The price of anarchy in competitive reverse supply chains with quality-dependent price-only contracts. T*ransportation Research Part E: Logistics and Transportation Review*, 89, 86-107.

Yoo, S. H., D. Kim, and M. S. Park, 2015. Pricing and return policy under various supply contracts in a closed-loop supply chain. *International Journal of Production Research*, 53(1), 106-126.

Yu, M., R. Yang, and L. Ma, 2014. The quota-based compensation plan in fashion retailing industry under asymmetric information. *Mathematical Problems in Engineering*, 263419.

Yue, J., J. Austin, M. C. Wang, and Z. Huang, 2006. Coordination of cooperative advertising in a two-level supply chain when manufacturer offers discount. *European Journal of Operational Research*, 168(1), 65-85.

Zeballos, L. J., M. I. Gomes, A. P. Barbosa-Povoa, and A. Q. Novais, 2012. Addressing the uncertain quality and quantity of returns in closed-loop supply chains. *Computers & Chemical Engineering*, 47, 237-247.

Zeng, A. Z., 2013. Coordination mechanisms for a three-stage reverse supply chain to increase profitable returns. *Naval Research Logistics*, 60(1), 31-45.

Zhang, C. T., and M. L. Ren, 2016. Closed-loop supply chain coordination strategy for the remanufacture of patented products under competitive demand. *Applied Mathematical Modelling*, 40(13), 6243-6255.

Zhang, L.H., J.G. Wang, and J.X. You, 2015. Consumer environmental awareness and channel coordination with two substitutable products. *European Journal of Operational Research*, 241(1), 63-73.

Zhang, M., X.D. Zhao, and Y.N. Qi, 2014b. The effects of organizational flatness, coordination, and product modularity on mass customization capability. *International Journal of Production Economics*, 158, 145-155.

Zhang, P., Y. Xiong, Z.K. Xiong, W. Yan, 2014a. Designing contracts for a closed-loop supply chain under information asymmetry. *Operations Research Letters*, 42(2), 150-155.

Zhao, S.L., and Q.H. Zhu, 2015. Remanufacturing supply chain coordination under the stochastic remanufacturability rate and the random demand. *Annals of Operations Research*, 1-35.

Zhao, Y., and Y. S. Fan, 2007. Implementation approach of ERP with mass customization. *International Journal of Computer Integrated Manufacturing*, 20(2-3),160-168.

Zou, Q.M., and G.Y. Ye, 2015. Pricing-decision and coordination contract considering product design and quality of recovery product in a closed-loop supply chain. *Mathematical Problems in Engineering*, 593123.